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THE NAVAL STORES INDUSTRY

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the need for improved methods, for attention to detail, is imperative if the industry is to have a future. Ways of collecting the gum which will give the maximum amount for the longest time with the least injury to the tree and methods of distillation which will insure turpentine and rosin of the best grade are things which every operator might well make the subject of study. Nowhere more than in the naval stores industry will close attention to detail coincide with successful operation.

This bulletin reviews the present status of the naval stores industry and the progress which has been made in improving the methods of collecting and distilling the gum.[1] Information is also presented on the supply of timber at present available for turpentine operations.

The publications listed in the latter part of this bulletin have been drawn upon in its preparation, and acknowledgement is made to the several authors.

HISTORY OF THE INDUSTRY IN THE UNITED STATES.

The earliest mention of turpentine and rosin seems to exist in a manuscript dated 1610, preserved in the Public Record Office, London, and entitled "Instructions for suche things as are to be sente from Virginia."[2]

"Hard pitche," "Tarre," "Turpentine," and "Rozen" are also mentioned in the "Booke of the Commodities of Virginia," issued presumably about the same time.

Pitch and tar were the chief products of the industry up to the middle of the eighteenth century. Their extensive use in the construction and maintenance of sailing vessels caused them to be called "naval stores," a term now applied to the turpentine and rosin industry, which has supplanted the production of tar and pitch.

The manufacture of turpentine and rosin in North Carolina was described by Schoepf in 1783–84. Pitch and tar, however, had been staple products since 1700. Norfolk was the great shipping point for Virginia and northeastern North Carolina.

The method of boxing the trees for collecting the crude gum was the same as that employed to-day, but the names of some of the operations have changed, such as "cornering" in place of "notching," and "virgin dip" in place of "pure dippings."

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[1] The Bureau of Chemistry of the Department of Agriculture is now investigating problems connected with the distillation of turpentine, and has offered helpful suggestions in the case of this bulletin.

[2] Among the instructions is the following: "Pyne trees, or ffirre trees are to be wounded wthin a yarde of the grounde, or boare a hoal wth an agar the thirde pte into the tree, and lett yt runne into anye thinge that maye receyue the same, and that w^{ch} yssues owte wilbe Turpentyne worthe 18£ Tonne. When the tree beginneth to runne softelye yt is to be stopped vp agayne for p^{re}serveinge the tree."

"Pitche and tarre hath bene made there and we doubte not but wilbe agayne, and some sente for a sample, your owne tournes beinge firste served."

Previous to 1800 very little of the crude turpentine was distilled at the point of production. Tapping operations were conducted, so far as possible, along navigable streams and inlets. The crude turpentine was then shipped to Wilmington, Philadelphia, and New York, and there reshipped to England for distillation. Up to the year 1820 the production of turpentine and rosin was quite unimportant and limited to the demands of domestic industries. The rosin manufactured was worth very little, the price dropping to 25 cents a barrel and even lower, so that it could no longer be handled at a profit.

Copper stills were introduced in 1834, and greatly improved manufacturing conditions. Previously the distillations had been conducted in crude cast-iron retorts that gave very poor results, both as to quantity and quality of the products.

Up to the year 1838 the industry had not advanced south of the Cape Fear River, the belief being that the pines farther south would not flow sufficiently. This error was soon discovered through a few experiments, and the practically untouched belt of longleaf pine forest extending from the Carolinas to Texas was gradually invaded.

Increasing demands for turpentine in the varnish and paint industries; its utilization as a solvent for rubber and as an illuminant when mixed with alcohol, and the passage of the British free trade law of 1846 combined to stimulate production. In proportion as the demand for turpentine increased a greater amount of rosin was manufactured than could be utilized in the arts, and so went to waste.

The Civil War had a depressing effect upon the industry. Only about two-thirds of the number of establishments reported for 1860 were in operation in 1870.

STATISTICS OF PRODUCTION.

Except for the period between 1860 and 1870, the naval stores industry has had a steady growth, so far as the value of its products is concerned. The market prices are subject to great variation,[1] not only according to supply and demand, but also through manipulation on the exchange. Figure 1 shows the high and low prices by years since 1901 for turpentine and for two grades of rosin.

During the last five years the average annual production, in round numbers, has been 31,800,000 gallons of turpentine and 3,700,000 barrels of rosin. Over half of the products are exported, this country largely supplying the world. France, Austria, Spain, Portugal, India, Greece, and other countries also produce naval stores, but the amounts are relatively small, as may be seen from Tables 1 to 4, which show the exports and imports of turpentine and rosin by various countries from 1901 to 1912.

[1] During the season 1909–10 the lowest price of turpentine per gallon was 35½ cents, while during 1910–11 the high-water mark of $1.07 was reached. The lowest quotation ever posted by the Savannah Board of Trade was on Sept. 4, 1896, when turpentine brought but 22 cents a gallon.

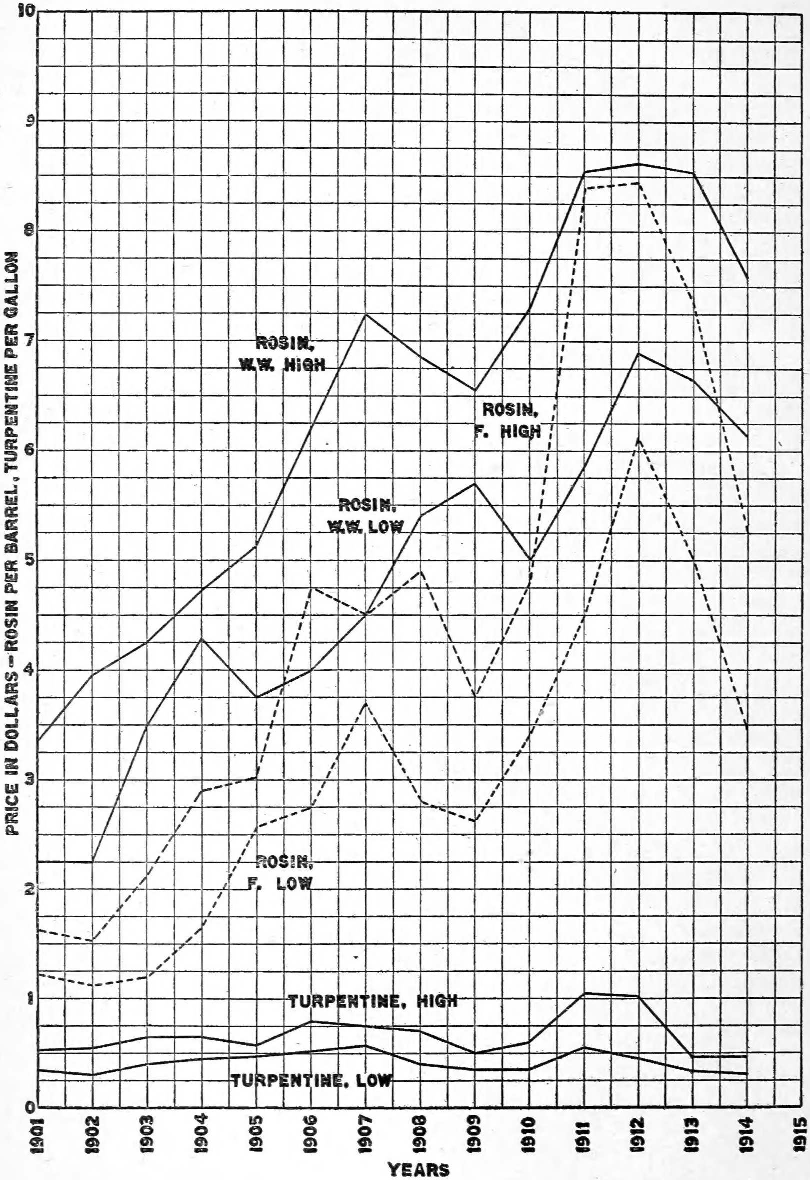

FIG. 1.—High and low prices by years since 1901 for turpentine and two grades of rosin.

TABLE 1.—*Exports of turpentine (gallons) by various countries, 1901–1910.*

Country.	1901	1902	1903	1904	1905
France	833,918	925,784	1,975,943	1,459,282	3,179,073
Germany [1]	565,174	502,434	612,052	569,644	520,745
Netherlands	941,518	1,288,866	988,049	876,921	972,704
Russia	1,483,439	1,516,096	1,887,430	2,163,759	2,504,423
Spain	[2] 1,089,669	[2] 1,089,669	[2] 1,089,669	[2] 1,089,669	[2] 1,089,669
United States	20,627,633	18,620,317	15,651,937	16,426,756	15,614,323
Other countries	60,000	60,000	72,000	113,000	90,000
Total	25,601,351	24,003,351	22,277,080	22,669,031	23,970,937

Country.	1906	1907	1908	1909	1910
France	3,367,337	2,538,689	2,397,686	2,400,228	2,851,038
Germany [1]	460,731	349,552	433,235	380,385	429,499
Netherlands	1,400,631	165,771	1,851,918	2,068,870	1,812,021
Russia	2,456,844	2,705,255	1,773,655	1,833,377	2,473,311
Spain	[2] 1,089,669	907,429	1,131,140	1,150,493	1,169,615
United States	16,182,500	17,176,843	19,433,181	16,061,783	14,252,321
Other countries	106,000	95,000	226,000	444,000	576,000
Total	25,063,712	25,448,539	27,246,815	24,339,136	23,563,805

[1] Not including free ports prior to Mar. 1, 1906. [2] Average 1907–1910.

TABLE 2.—*Imports of turpentine (gallons) by various countries, 1901–1910.*

Country.	1901	1902	1903	1904	1905
Austria-Hungary	1,762,578	1,821,949	1,739,705	2,071,834	2,021,465
Canada	923,370	908,151	890,135	910,443	948,100
Germany	8,435,688	8,077,409	8,300,166	8,438,872	8,539,824
Italy	658,410	663,187	771,457	816,621	687,284
Netherlands	1,895,548	3,245,583	2,729,788	2,220,134	2,248,032
United Kingdom	9,701,051	7,942,324	8,012,184	7,907,419	7,693,933
Other countries	2,218,199	1,655,645	1,931,217	2,453,412	2,199,739
Total	25,594,844	24,314,248	24,374,652	24,818,735	24,338,377

Country.	1906	1907	1908	1909	1910
Austria-Hungary	2,218,072	2,291,131	2,409,689	2,439,635	2,502,527
Canada	1,011,283	1,028,936	1,081,180	1,141,238	1,044,734
Germany	9,966,690	8,986,011	10,088,770	9,764,051	8,659,883
Italy	948,162	921,278	1,020,117	824,643	855,538
Netherlands	2,711,769	3,035,996	3,932,317	2,785,377	2,696,243
United Kingdom	7,673,758	7,515,293	8,656,464	6,522,833	7,041,316
Other countries	3,174,227	3,172,429	2,947,196	2,478,389	2,848,791
Total	27,703,961	26,951,074	30,135,733	25,956,166	25,649,032

TABLE 3.—*Exports of rosin (barrels) by various countries, 1901–1910.*

Country.	1901	1902	1903	1904	1905
Austria-Hungary	12,933	12,066	11,884	12,955	12,044
Germany	150,918	120,558	159,115	162,918	165,606
Netherlands	233,833	267,343	225,136	299,794	209,085
Russia	140,289	135,978	125,565	147,971	174,273
Spain	10,000	17,143	23,929	32,143	56,429
United States	2,691,523	2,629,519	2,563,977	2,501,521	2,258,126
Other countries	1,168	2,095	5,820	9,765	20,266
Total	3,240,664	3,184,702	3,115,426	3,167,067	2,895,829

Country.	1906	1907	1908	1909	1910
Austria-Hungary	11,266	10,784	9,399	8,188	7,255
Germany	164,602	196,495	217,706	171,497	198,865
Netherlands	284,104	273,832	309,885	202,249	199,335
Russia	147,161	174,607	139,826	90,410	137,661
Spain	51,786	61,967	60,394	53,183	80,602
United States	2,481,269	2,636,149	2,601,181	1,984,525	2,269,339
Other countries	20,045	22,455	18,340	20,114	43,294
Total	3,160,233	3,376,289	3,356,731	2,530,166	2,936,351

TABLE 4.—*Imports of rosin (barrels) by various countries, 1901–1910.*

Country.	1901	1902	1903	1904	1905
Austria-Hungary	284,128	208,749	257,576	231,515	223,149
Canada	140,639	28,001	57,033	93,118	67,525
Germany [1]	839,724	705,489	844,585	834,069	743,905
Russia	237,030	234,733	241,735	234,261	213,489
United Kingdom	692,980	721,487	655,742	712,778	632,181
Other countries	777,341	870,925	770,066	935,580	842,835
Total	2,971,842	2,769,384	2,826,737	3,041,322	2,723,084

Country.	1906	1907	1908	1909	1910
Austria-Hungary	261,980	265,415	294,012	250,822	253,425
Canada	68,454	78,058	60,729	82,026	85,438
Germany [1]	840,351	884,393	1,022,197	774,308	857,970
Russia	216,361	242,655	269,738	201,176	223,629
United Kingdom	624,988	634,051	613,209	530,192	568,914
Other countries	859,326	953,244	1,031,975	826,077	901,688
Total	2,871,460	3,057,816	3,291,860	2,664,601	2,891,064

[1] Not including free ports prior to Mar. 1, 1906.

Tables 5 and 6 show the growth and present magnitude of the turpentine and rosin industry in the United States and the large amount of capital involved in producing and exporting naval stores. It would seem from Table 6 that the production of turpentine and rosin in this country has reached its maximum, and this conclusion is further borne out by a survey of the stumpage supply still available for naval stores operations (p. 41). Table 7 shows the exports of naval stores by States.

TABLE 5.—*Number of establishments and quantity and value of turpentine and rosin produced—United States.*

[Figures taken from reports of the Bureau of the Census.]

Year.	Number of establishments.	Turpentine.		Rosin.		Combined value of turpentine and rosin.
		Gallons.	Value.	Barrels.	Value.	
[1] 1913		32,000,000		3,815,000		
[1] 1912		34,000,000		4,000,000		
[1] 1911		31,900,000		3,800,000		
1910		27,750,000	$17,680,000	3,651,000	$18,255,000	$35,935,000
1909	1,585	28,941,000	12,654,000	3,258,000	12,577,000	25,231,000
1908	1,696	36,589,000	14,112,000	4,288,000	17,795,000	31,907,000
1907	1,629	34,181,000	18,283,000	3,999,000	17,317,000	35,600,000
1904	1,287	30,687,000	15,170,000	3,508,000	8,726,000	23,896,000
1900	1,503	38,488,000	14,960,000	2,563,000	5,129,000	20,090,000
1890	670					[2] 8,077,000
1880	508					[2] 5,877,000
1870	227					[2] 3,585,000
1860	625					[2] 6,468,000
1850	856					[2] 2,856,000
1810		122,900	176,650	[3] 2,000		

[1] According to Naval Stores Review of Apr. 4, 1914.
[2] Combined value of all naval stores.
[3] Includes pitch.

TABLE 6.—*Quantity and value of spirits of turpentine and rosin exported, 1860–1913.*

[Figures from the Bureau of the Census.]

Year (ending June 30).	Turpentine		Rosin.	
	Gallons.	Value.	Barrels.	Value.
1913	21,039,597	$8,794,656	2,806,046	$17,359,145
1912	19,599,241	10,069,135	2,474,460	16,462,850
1911	14,817,751	10,768,202	2,189,607	14,067,335
1910	15,587,737	8,780,236	2 144,318	9,753,488
1909	17,502,028	7,018,058	2,170,177	8,004,838
1908	19,532,583	10,146,151	2,712,732	11,395,126
1905	15,894,813	8,902,101	2,310,275	7,069,084
1903	16,378,787	8,014,322	2,396,498	4,817,205
1900	18,090,582	8,554,922	2,369,118	3,796,367
1890	11,248,920	4,590,931	[1] 1,601 377	[1] 2 762,373
1880	7,091,200	2,132,154	[1] 1,040,345	[1] 2,368,180
1870	3,246,697	1,357,302	[1] 583,316	[1] 1,776,625
1860	4,072,023	1,916,289	[1] 770,652	[1] 1,818,238

[1] Turpentine included with rosin.

TABLE 7.—*Exports of spirits of turpentine and turpentine and rosin by decimal years, 1860–1900.*

[Figures from Twelfth Census of the United States, No. 126.]

State.	1900		1890		1880	
	Spirits of turpentine.	Turpentine, rosin, and pitch.	Spirits of turpentine.	Turpentine, rosin, and pitch.	Spirits of turpentine.	Turpentine and rosin.
	Gallons.	*Barrels.*	*Gallons.*	*Barrels.*	*Gallons.*	*Barrels.*
Alabama	153,018	58,646	210			22,373
Alaska		7				
California	45	535		25	6,055	125
Delaware						1,375
Florida	795,267	243,452	1,742	940	25,728	12,215
Georgia	14,623,328	1,408,928	7,251,929	841,217	570,549	91,909
Louisiana	212,031	47,890	599	1,128	276	5,089
Maine	34,103	831	4,062	79	90	528
Maryland	111	174,416	3,002	50,928	754	7,623
Massachusetts	2,044	18,359	29,418	7,038	50,915	3,612
Michigan	307,716	3,879	5,434	1,939	7,639	103
Minnesota		5	7,053	5	362	17
Mississippi		2				10
Montana and Idaho	11					
New York	1,630,164	252,801	894,287	267,801	1,105,100	227,746
North Carolina	53,974	139,767	1,751,270	304,100	3,630,009	497,456
North and South Dakota	39,649	1,774				
Ohio	40					
Oregon			650			
Pennsylvania	121	144	500	1,201	1,443	7,974
Rhode Island						
South Carolina		21,248	1,293,389	140,399	1,691,447	158,563
Texas	659	126	1,515	412	762	42
Vermont	235,776	15,631			41	
Virginia				2,491	30	3,585
Washington	2,525	923	3,860			
Wisconsin				1		
Total	18,090,582	2,389,364	11,248,920	1,619,704	7,091,200	1,040,345

TABLE 7.—*Exports of spirits of turpentine and turpentine and rosin by decimal years, 1860–1900*—Continued.

State.	1870		1860	
	Spirits of turpentine.	Turpentine and rosin.	Spirits of turpentine.	Turpentine and rosin.
	Gallons.	*Barrels.*	*Gallons.*	*Barrels.*
Alabama	462	885		500
California	1,965	76	1,280	2
Connecticut			640	10
Florida	90	518		
Georgia		519	137	134
Louisiana	7,558	8,423	11,197	18,909
Maine		41		160
Maryland	6,104	30,626	38,080	20,268
Massachusetts	52,511	11,435	123,163	16,605
Michigan		32		
Minnesota		1		
New York	796,824	464,538	2,816,768	562,253
North Carolina	2,042,756	33,212	736,948	77,851
Ohio		1		
Pennsylvania	544	3,063	25,511	19,845
Rhode Island			200	534
South Carolina	337,530	25,279	315,099	50,753
Texas	273	318		
Vermont		2		80
Virginia	80	4,347	3,000	2,748
Total	3,246,697	583,316	4,072,023	770,652

NOTE.—The exports of turpentine and rosin from a State bear no relation to the amounts actually produced within the State, but to the possession of shipping centers for the naval stores trade.

COMMERCIAL UTILIZATION OF PRODUCTS.

TURPENTINE.

Paints and varnishes.—The greater portion of the turpentine produced finds its way into paints and varnishes. The three main classes of varnishes are spirit varnishes, linseed-oil varnishes, and turpentine varnishes. The turpentine varnishes are made by dissolving resins, such as amber, copal, etc., in hot turpentine and are tough and flexible. Linseed-oil varnishes are often diluted with turpentine.

Turpentine is used in paints and varnishes chiefly as a thinner, of which the properties demanded are solvent action, oxidizing power, penetration, and proper evaporation.

Print goods.—Turpentine finds an important use in the manufacture of cotton and woolen print goods in preventing "bleeding," or running together of colors, where several colors are printed at the same time. It also prevents the color from penetrating the fabric, which is particularly important in the case of woolen goods if unevenness of the material is to be avoided.

Camphor.—Many attempts have been made to produce camphor from turpentine on a commercial scale, but so far none has been entirely successful. However, terpineol, terpin hydrate, and similar bodies are manufactured from turpentine in considerable quantities.

Rubber industry.—Turpentine is important as a solvent for rubber, caoutchouc, and similar substances.

ROSIN.

Rosin is employed extensively in the manufacture of soap, paper, oilcloth, linoleum, sealing wax, fly paper, printing inks, roofing materials, brewer's pitch, electric wiring, lubricating compounds, medicinal preparations, etc.

Rosin soap.—Rosin has the property of combining with alkalies, such as caustic soda and potash, to form "soaps" which are readily soluble in water. Their color is yellowish or yellowish-brown, depending on the color of the rosin used. At ordinary temperatures rosin soaps have the consistency of butter, and on account of their relative cheapness, are usually added to the hard soaps made from tallow. In themselves, however, rosin soaps possess valuable properties, and their addition to tallow or other hard soaps can not always be considered an adulteration.

Resin driers.—The metallic salts of the resin acids are known as driers. They are made by adding a solution of the salt of a metal such as manganese to a solution of "rosin soap" when the insoluble manganese resinate precipitates; or the rosin is fused with the metallic oxide. These metallic resinates, known as "Japan driers," cause the oxidation or "drying" of oil paints and varnishes and are extensively used for this purpose. The lead and manganese resinates are used most frequently.

The various enamels used in ceramics consist of resinates of the various heavy metals. The resinates are dissolved in turpentine and the resulting solution painted on the earthenware, after which the vessels are "fired."

Rosin size.—One of the most important uses of rosin is as a "size" or coating for writing or printing papers, which must take ink. A rosin soap, containing about 3 pounds of rosin to 1 of soda, is added to the pulp in the hollander, and after that a solution of alum. The latter decomposes the rosin soap, and the result is a precipitate of free rosin and some alumina which becomes entangled in the fibers of the paper. When the paper is passed over hot calendar rolls in finishing, the rosin fuses to a smooth, varnish-like layer on the surface.

Brewers' pitch.—Barrels intended to hold beer or other fermented beverages are coated with brewers' pitch, which renders the barrels easy to clean and improves the taste of the beer. The pitch is made of pure rosin, with the addition of a certain amount of turpentine or refined rosin oil to prevent brittleness. Some manufacturers make the pitch supple by adding rosin soap.

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Products of the distillation of rosin.—When rosin is heated at temperatures above its melting point it decomposes[1] into gases and oils.

The lightest of these oils, rosin spirit or pinoline, is used as an illuminant, and also as a solvent, especially as a substitute for turpentine. The heavier rosin oils are used in the manufacture of printing inks and lubricants. Wagon grease is often made by boiling rosin oil with lime.

The distillation of rosin is carried out on a large scale in Germany and France, the darker grades of rosin imported from America being used for this purpose. Comparatively little is distilled in the United States.

Lampblack.—Rosin oil can be used for the manufacture of lampblack which, from the standpoint of color and minuteness of division, is of the highest quality. The finest grades are used in the manufacture of india ink, in lithography, and in artistic printing with copper plates.

FORMATION AND FLOW OF RESIN IN THE LIVING TREE.

Resin suitable for the production of naval stores is found only in in coniferous trees. Moreover, only pines yield resin abundantly, and of these only two species, longleaf pine (*Pinus palustris*) and, to a small extent, slash pine[2] (*Pinus heterophylla*) are tapped in the United States.

No universally accepted theory dealing with the formation of resin has as yet been advanced. It is generally conceded, however, that resin is formed as a by-product during the transformation of food materials, such as starch, into woody tissue. The resin is stored in two systems of elongated passages or resin ducts. In one system the ducts are parallel to the pith of the tree; in the other they lie horizontally in radial planes. The ducts form in the growing tissue or cambium layer just beneath the bark, the two systems intersecting to form a continuous network of resin passages.

When the cambium layer is cut the growth of tissue near the wound is stimulated, and the number of resin ducts, and consequently the amount of resin formed, is considerably increased. The area in which additional or secondary resin ducts are formed apparently extends from 2 to 3 inches above and to a lesser distance below the wound.

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[1] The products resulting from distillation and their percentages are as follows:

Losses (rosin adhering to walls of still) per cent..	1.0	Light oil (turbulent)................per cent..	5.0
Gases evolved........................do....	9.0	Light oil, hearts....................do....	58.0
Acid water...........................do....	3.5	Blue oil and red oil.................do....	16.0
Rosin spirit or pinoline.............do....	3.5	Residue, coke........................do....	4.0

[2] Slash pine is of comparatively infrequent occurrence, but is tapped wherever found on areas being turpentined.

The additional ducts require from 2 to 4 weeks for their formation full of resin.

If a new cut is made just above the old one, after the additional ducts have had a chance to form, the flow will show a large increase over that obtained from the original wound, due to the additional ducts.

Depth of cut.—Since the additional ducts form only in the cambium layer, and since they yield by far the greater part of the resin, cutting deeper than this layer induces but little additional flow. In commercial operations the depth of the cuts or "streaks" runs from one-half to one inch. Such streaks are, of course, much deeper than necessary, and to just that extent tend to reduce the vitality of the tree and, in consequence, its ability to give a sustained flow. Tests have shown that a greater average flow over a four-year period can be obtained from trees with streaks 0.4 inch deep than from trees with streaks 0.7 inch deep. In any case, shallow streaks give fully as large a flow of resin as deep ones, when the period of tapping extends over two years or more. The tools used at present, however, make it difficult to cut shallow streaks, while the custom of deep chipping is pretty firmly established through long usage.

Height of chip.—When a new "streak" is made the flow of gum is at first comparatively rapid, but gradually decreases until at the end of a week it has practically ceased. The diminution of flow is presumably caused by the gradual hardening of the resin in the exposed ends of the ducts, which results in plugging them. It then becomes necessary to chip again. In deciding how thick a chip should be taken off, or how much the "face" or scar should be increased in height to give a new flow, it should be remembered that the bulk of the resin is produced in the region between the wound and a point about two inches above it. For this reason, no more of the wood immediately above the old wound should be removed than is necessary to open up the ends of the resin ducts in which the gum has hardened. Since in the space of a week the resin does not harden in the ducts for a distance greater than one-fourth inch from the surface of the cut, a chip that increases the height of the face one-fourth inch is all that is necessary. In practice, the vertical height of the new streak frequently exceeds 1 inch, thus eliminating practically one-half of the wood where most of the resin is being produced, and decreasing the productive period of the tree four times as rapidly as necessary. With the present type of tool it is difficult to cut a one-fourth inch streak, and, moreover, the difficulty of changing an old established custom again presents itself. The chipping tool should always be sharp. A dull edge tends to crush the ends of the resin ducts instead of cutting them clean, thus preventing a free flow.

Frequency of chipping.—Table 8 shows the rate with which the gum flows.

TABLE 8.—*Rate of exudation of gum from "chipped" longleaf pine.*

Day.	Grams of gum.	Total exudation.	Day.	Grams of gum.	Total exudation.
		Per cent.			*Per cent.*
First	113.0	67.26	Fifth and sixth	9.0	5.36
Second	22.5	13.39	Seventh	1.0	0.59
Third	13.5	8.04			
Fourth	9.0	5.36	Total	[2] 168.0	100.00
Fifth	(1)	....			

[1] No weighing. [2] 168 grams equal 0.37 pound.

It is seen that 88 per cent of the total flow occurs during the first three days. As the resin ducts become plugged with coagulated or crystallized gum the flow gradually ceases, and the gum thereafter produced is stored in the resin ducts until the ends are again opened. When the ducts immediately above the wound become full, the resin tends to diffuse or soak into the wood further removed from the bark This diffused resin does not drain out when the tree is wounded, and for this reason chipping should be done often enough to insure that the active ducts immediately beneath the bark and above the wound will not remain full of gum. On the other hand time should be allowed between chippings for a new supply of gum to form. In practice, trees are chipped once a week. It is possible that more frequent chipping would give a greater yield of gum for a short period (one or two years), but at the same time it might further reduce the vitality of the tree and so result in a smaller total yield over a longer period. The increased yield, moreover, must be enough to justify the additional expense. Experiments are needed to show how the rate of flow is affected by frequency of chipping in operations extending over different periods of years.

Size and number of faces.—The scar on the tree caused by successive chippings is usually about 14 inches wide, and is known as the "face." Wounding the tree, of course, diminishes its vitality by interfering with the transmission of water from the roots to the leaves and of nutritive matter from the leaves to the roots. When a small tree, 8 or 10 inches in diameter, is chipped, it usually either dies outright or its further growth is greatly retarded, even though the width of the face is kept at the minimum.

PRINCIPLES UNDERLYING THE DISTILLATION OF CRUDE GUM.

The crude gum was formerly distilled without the addition of water; in consequence the quality of the resulting turpentine and rosin was poor. The yield of turpentine was very low, but it was impossible to increase it without coloring the liquid yellow with the

decomposition products of the rosin. Other conditions being the same, the question of obtaining water-white turpentine and rosin depends largely on the temperature.[1] The introduction of the practice of using water during the distillation increased the yield and quality of the turpentine and resulted in rosin of a lighter color.

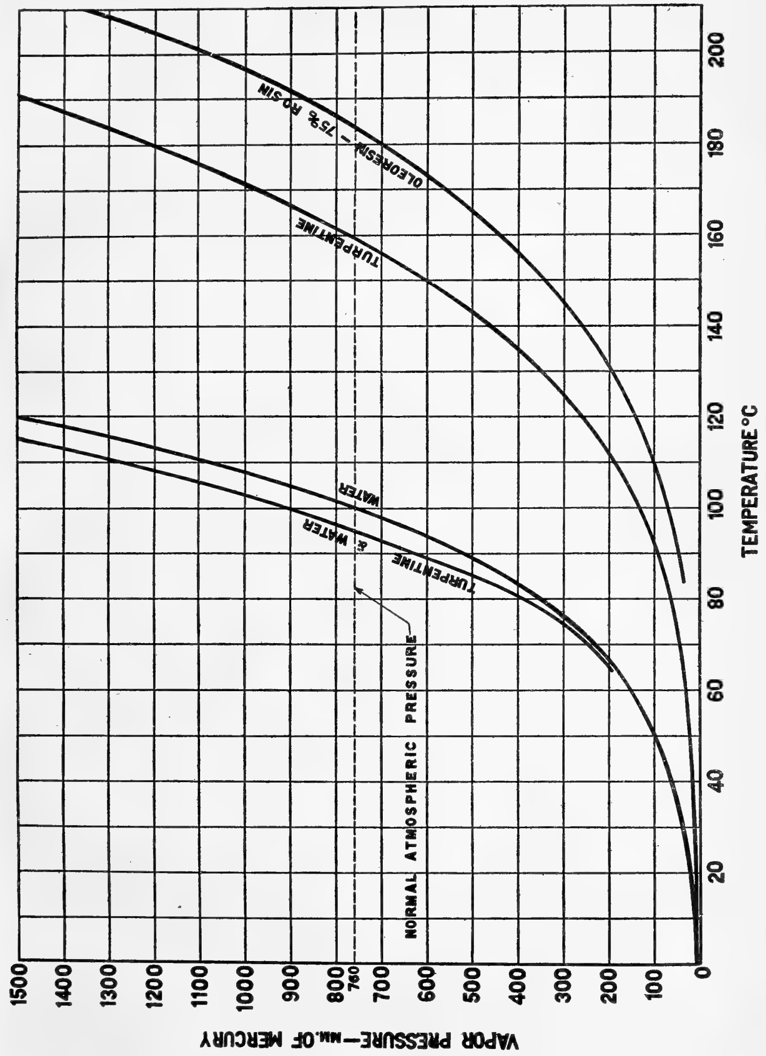


FIG. 2.—Relation of vapor pressure and temperature for turpentine, water, and mixtures.

Turpentine begins to boil at about 313° F.[2] and the greater portion of fresh turpentine distills between 317° F. and 324° F. (See fig. 2). If an attempt is made to distill turpentine direct from a gum contain-

[1] It should be borne in mind, however, that it is impossible to make light rosin from scrape and dip from old boxes or when the gum contains large amounts of trash by following the ordinary methods of production. See p. 27.

[2] 203° F. = 95° C. 302° F. = 150° C. 324° F. = 162° C. 207° F. = 97° C. 313° F. = 156° C. 363° F. = 184° C. 212° F. = 100° C. 317° F. = 158° C. 392° F. = 200° C.

ing 75 per cent rosin and 25 per cent turpentine, the turpentine in the absence of water will not begin to boil at 313° F., but at about 363° F., owing to the presence of the rosin. Rosin does not begin to decompose perceptibly until a temperature of about 392° F. is reached, but after the turpentine in the gum begins to distill off at 363° F., the temperature of the gum rises rapidly. For this reason, only a portion of the turpentine will be obtained before the decomposition of the rosin begins. In fact, it would be impossible to obtain all the turpentine in the gum, and that secured would be yellow, while at such high temperatures the rosin would also be quite dark. Practice has shown that the best quality of turpentine and rosin is obtained at a temperature of 302° F., which calls for the use of water in the distillation.

A liquid begins to boil when the pressure of its vapors is equal to or slightly exceeds the pressure of the atmosphere. Thus, water boils at 212° F. and turpentine at 313° F. Turpentine and water are nonmiscible liquids, and according to physical law will distill together when the sum of their vapor pressures equals the vapor pressure of the atmosphere. Theoretically a turpentine, with a constant boiling point of 313° F., and water will distill together at a temperature of 203° F., the proportion of water and turpentine in the distillate remaining practically constant until one of the liquids is exhausted. Owing, however, to the complex nature of ordinary turpentine with its wide range of boiling points, turpentine and water will begin to distill at about 203° F., and the temperature will rise finally to about 212° F. The distillate will at first contain about 60 per cent of turpentine by volume, the turpentine content of the distillate gradually decreasing to practically zero.

In a mixture of gum (containing 75 per cent rosin and 25 per cent turpentine) and water, distillation will not begin at 203° F., as in the case of pure turpentine and water, but at 207° F. As the gum grows poorer in turpentine the temperature rises until 212° F. is reached. At this temperature all the turpentine will have distilled over.

In actual practice all the turpentine does not distill at 212° F. when water is added, owing to the physical difficulty of bringing more than the surface of the gum in contact with the water. On this account the gum must be heated to a temperature that will make it readily fluid and produce convection currents in lieu of stirring. If live steam were introduced into the mass all the turpentine could be removed below 212° F.

COMMERCIAL METHODS OF COLLECTING CRUDE GUM.

BOX SYSTEM.

Cutting the boxes.—The first operation in turpentining by the box method consists in cutting a cavity (fig. 3) into the base of the tree for holding the crude gum. This cavity, called the "box" is cut

during the winter months. The work is performed by a squad of six or seven negroes under an experienced overseer, who tallies the boxes. The cutting is done by piecework, and each negro has a number which he calls as soon as he has finished a box. The tool used is an ax with a long narrow blade. An experienced man will cut a box

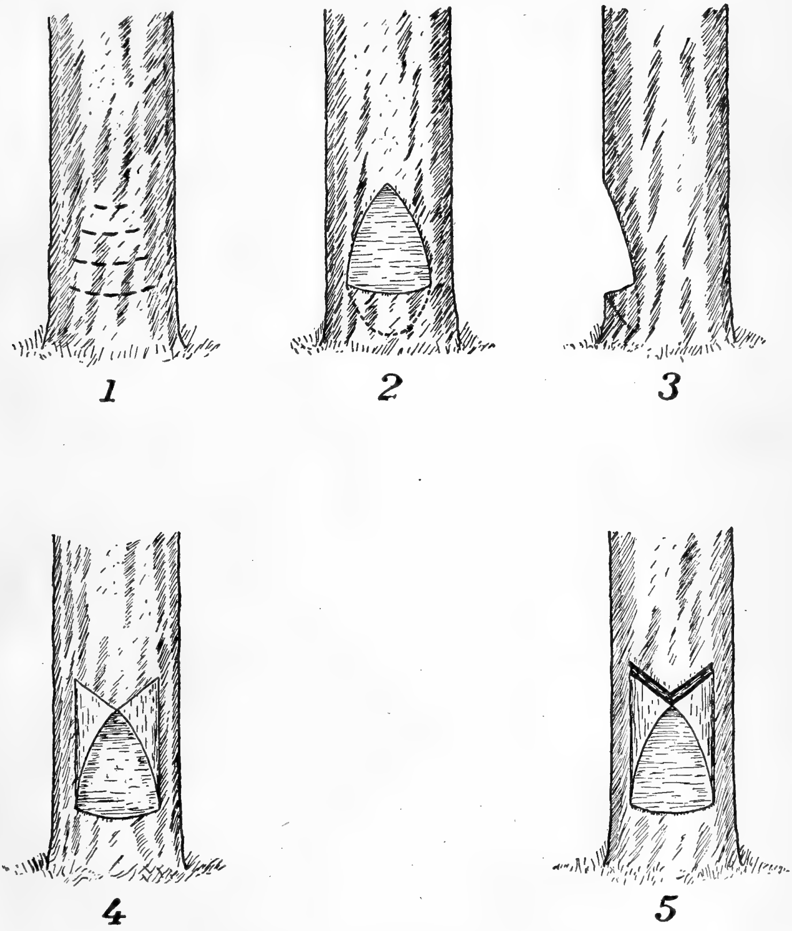


FIG. 3.—Operations in cutting a "box."

1. First step in cutting box. Gashing tree.
2. Finished box. Front view.
3. Finished box. Side view.
4. Cornered box.
5. First streak.

with surprising neatness in from four to eight minutes. The dimensions of the box vary somewhat with the size of the tree. Usually a box is 12 to 14 inches wide, 7 inches deep, $3\frac{1}{2}$ to 4 inches from front to back, and holds about 3 pints. Shaped like a distended pocket, it is cut into the base of the tree 8 to 12 inches above the ground,

although in second-growth timber this distance may be only from 5 to 6 inches.

The position of the box depends on the configuration of the tree. If the latter leans, as is usually the case, the first box is placed on the side opposite to the direction in which it leans, which is generally the position occupied by the most prominent root. When additional boxes are cut on a leaning tree, the loss occasioned by the gum falling outside the box increases each year the tree is bled; in some cases little, if any, resin reaches the box from the fourth year's chipping.

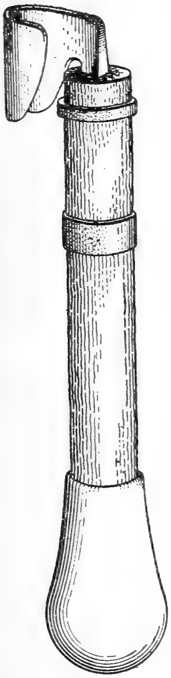


FIG. 4.—Hack with handle and weight.

Cornering.—Two or three weeks before the chipping season opens the "boxes are cornered" (fig. 3 (4)). The operation, which is done with an ordinary ax, consists in removing a triangular chip about 1 inch thick above the corners of the box, a right-handed and a left-handed man usually working together. The chip is removed by making one gash which rises obliquely from the apex of the triangular opening of the box and another gash which rises perpendicularly from the corner of the box to meet the former. This operation serves to form both a surface for future chipping and channels for guiding the flowing gum into the box.

Chipping.—The scarification of the tree, or chipping, begins in early spring, usually in March, and continues each week up to October or November, when the flow of gum practically ceases. The number of chippings is usually 32 per season, although owing to weather or labor conditions it may vary between 28 and 35.

The instrument used for chipping or making the "streak" is called a "hack" (fig. 4). It consists of a flat, steel blade $2\frac{1}{2}$ inches wide, bent into the shape of a U, measuring an inch between the sides.[1] The blade is fastened at right angles to one end of a wooden handle 18 inches long and 2 inches in diameter, to the opposite end of which is attached a pear-shaped iron weight weighing from 5 to 7 pounds; the blade and handle weigh about 1 pound.

The chipper (Pl. I, fig. 1) stands directly in front of the face and removes with the hack two strips of wood and bark one-half to three-fourths of an inch wide and one-half to $1\frac{1}{2}$ inches deep, parallel with the oblique gashes made in cornering. The removal of the two strips constitutes the "streak," which is in the shape of a V, having an angle of about 95°. The apex of the angle is called the "peak" and

[1] Three sizes of hacks are made. The blade described is for a No. 1 size hack.

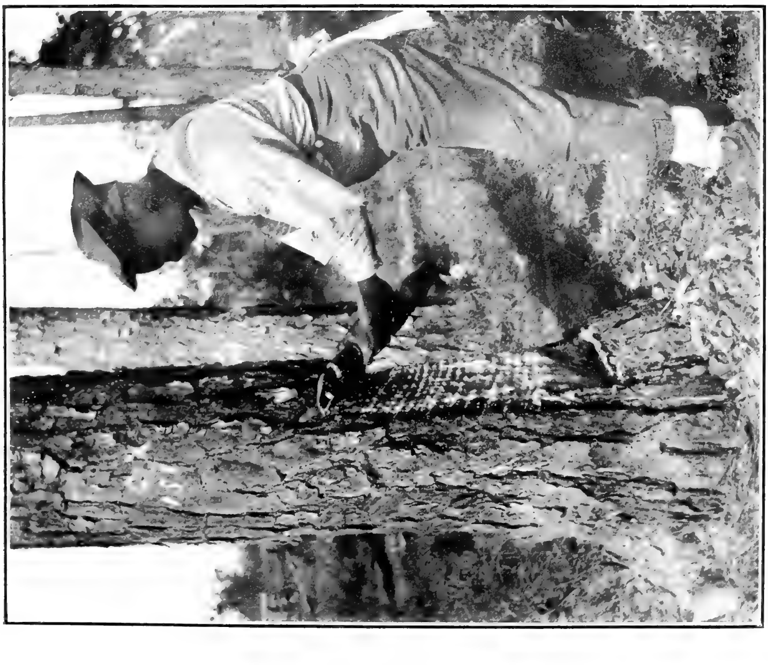


FIG. 1.—CHIPPING.

FIG. 2.—CUP AND GUTTERS.

Blaze below first streak 8 by 16 inches. Distance from gutter to peak of first streak 8½ inches, of which 7 inches, equivalent to 14 streaks, represents a loss of possible chipping height.

"PULLING."

This tree originally boxed; cups substituted later.

lies directly above the center of the box. The hack is given a quick, swinging motion, and the momentum furnished by the iron ball enables one side of a streak to be made with only two or three blows. Chippers are paid from 75 cents to $1 per thousand streaks, according to the condition of the crop and the scarcity of labor.

After the first two seasons the increased height of the face makes the use of a hack impracticable, and a "puller" is used in its place. This tool resembles the hack, except that the blade is closed and provided with a long handle. The streak is made by a steady pull (Pl. II) rather than with a quick hacking motion. After the fourth season the face is usually abandoned, since at that time a height of 8 feet is attained, beyond which it is not profitable to work a tree. Old faces 12 feet in height have been noted in Georgia, and others even higher in North Carolina and South Carolina.

Dipping.—The boxes fill with gum in three or four weeks and are "dipped" or emptied about seven times a season. The workman uses a tool called a "dipper", which has a flat trowel-shaped blade about 7½ inches long and 5½ inches wide. This dipper is thrust into the box under the gum, which is removed by a quick upward and outward motion and flipped into a portable bucket. Considerable skill is required to prevent loss of gum during the transfer. The bucket is emptied into barrels placed at convenient points throughout the woods. These barrels, provided with removable heads, are closed after filling, rolled upon wagons by means of skids, and taken to the still. Dippers receive from 50 cents to $1 per barrel, according to the nature of the territory covered.

Scraping.—A certain amount of the gum does not reach the box, partial evaporation of volatile oil leaving it too viscous to flow. Gum which is perfectly homogeneous and transparent immediately after exudation soon becomes opaque from the separation of white crystals of the resin acids, and doubtless the greater portion of the "scrape" results from the adherence of these separated crystals to the face. The amount of this hardened gum naturally increases with the height of the face. "Scrape" is essentially a product of longleaf pine (*Pinus palustris*), since slash pine (*Pinus heterophylla*) forms but small amounts, which it does not pay to collect. The scrape contains about half as much turpentine as the "dip" and gives a darker resin under similar conditions.

The scrape is collected but once a year—at the end of the season. The tools used, called "scrapers," are of two types. One type, the "pusher," has a flat, rectangular blade 4 inches long by 4½ to 5 inches wide. This is used during the first two years, the scrape being removed by downward thrusts of the tool. In most cases the necessary violence of the thrust results in removing large chips of wood along with the scrape. Another type of scraper has a blade shaped

like an equilateral triangle and in use is given a pulling motion downward.

The scrape is usually collected and distilled before the last dipping is made, since at the end of the season the danger of fire breaking out in the woods and burning the faces is very great. The dip in the boxes is not so great a source of danger, since it is usually more or less covered with water. In course of removal the scrape is considerably disintegrated, and if stored in the rosin barrels for any length of time the turpentine evaporates rapidly.

A wooden box, called a "scrape box," is used to receive the detached scrape. This box is about 2½ feet square and open at the top and at one end. The bottom at the open end is rounded inward and provided with an apron of burlap to form a close contact with the tree and prevent loss of scrape. The legs project sufficiently above the sides to serve as handles for dragging the box from tree to tree, though sometimes the box is provided with wheels. A box will hold from 100 to 150 pounds of scrape, which is transferred to rosin barrels and hauled to the still.

Raking.—After the crude gum has been collected the trash surrounding the base of the tree is "raked" away for a distance of 2½ to 3 feet to guard against fire. This operation is performed late in the fall, the tool used being a hoe with a broad, heavy blade. The turpentine woods are intentionally burned over once each season, to afford better forage for stock the following spring, to reduce the risk from accidental fires, and to remove brush and other materials which impede the workmen.

Crops.—The tracts of timber to be turpentined are divided into sections called "crops," a full crop consisting of 10,500 boxes.[1] Since each tree receives from one to four boxes, 4,000 to 5,000 trees, covering an area of 200 to 250 acres, are required to make one crop. For convenience in working, the crop is further divided into drifts, whose boundaries are defined by lines blazed on the trees. Each drift contains about 2,100 boxes, although this number varies considerably.

The average still has a capacity of 15 to 20 barrels, so in order to make two distillations per day with a still holding 20 barrels of crude gum the operator must work 20 crops, covering an area of four to five thousand acres. It is seldom profitable to work less than five crops.

CUP SYSTEMS.

Historical.—Until recent years the box system was the only one used in the United States for collecting resin. While no recent figures are available, it is probable that at present the number of cups

[1] In practice a "crop" consists of the number of faces a man can chip in from four to five days. Consequently a "crop" may vary from 7,000 to 10,000, owing to the topography of the country or density of the stand.

in use exceeds the number of boxes. During the past two or three years, however, it is estimated that cups have been hung on 75 per cent of the trees tapped.

The need of replacing the box with a cup hung against the tree was felt many years ago.

Mr. A. Pudigon patented a substitute for the box in 1868, and the device received a commercial test at Monks Corner, S. C., but was soon abandoned for some unknown reason. From that time on numerous substitutes have been invented, but none patented prior to 1903 proved a commercial success.

The first systematic attempt to improve the method of collecting gum was made at Bladenboro, N. C., by W. W. Ashe in 1894. A comparison on a limited scale was made between the French cup and gutter system and the box system, and the results showed a gain for the former of over 20 per cent in the value of the products collected.

The preliminary experiments begun in 1901 by Dr. Charles H. Herty, of the Forest Service, and continued in 1902, mark the turning point in the method of collecting crude gum. Cups were first used on an extensive scale in 1904, and since that time their use has become more or less general.

Classes of cup systems in use at present.—The cup systems may be divided into four classes.

Class 1. (Plates III and IV.) The gum flowing down the face is guided into the cup by means of two galvanized-iron gutters inserted in cuts in the tree. These gutters are 2 inches wide and from 6 to 12 inches long, depending on the size of the tree, and are bent into an obtuse angle. Sufficient bark and sapwood are removed from the tree to form a central vertical ridge with two flat faces on either side of it. The gutters are inserted in inclined gashes made by a broadax in the flat surfaces. It is necessary that these surfaces be flat, in order that the straight edge of the gutter may enter the face along its entire length, so that gum can not flow between the gutter and the tree. The lower gutter is placed so as to project at least two inches beyond the other at the center of the ridge, in order to guide the gum into the cup, which is hung just below the lower gutter on a nail. The cups are of galvanized iron or of clay, and vary in shape. Those resembling an ordinary flowerpot are the most common. Their capacity is 1, 1½, or 2 quarts. The blazes made for inserting the gutters extend below the latter and produce a flow of resin which is not only wasted but serves to coat the base of the tree, and thus makes the face more susceptible to fire. The workman frequently makes the blaze too large, as is shown in Plate III, figure 1, and there is a tendency in placing the gutters to spread them too far apart, losing in many cases as much as 20 inches of chipping surface. It is entirely possible to place the cups and gutters on a normal tree so that the first streak

will be 12 inches from the ground (Plate III, fig. 2). In Plate IV, figure 1, the first streak is 17 inches higher than necessary. On the basis of one-half inch streaks this means that a height sufficient for 34 chippings, or for a whole season, has been lost.

Class 2. (Plates V and VI.) The gum flowing from the face is guided into the cup by means of a flat oblong piece of galvanized iron, with the ends slightly upturned, called an "apron." The edge of the apron to be inserted in the tree is concave to conform to the tree's shape. In some cases the aprons are made in two pieces, riveted together at the ends, so as to allow them to be adjusted to the curvature of each particular tree. They are also made in two separate pieces. The aprons are inserted in a horizontal gash at the base of the tree made with a broadax having a flat blade with a concave edge. When inserting the apron a small blaze about 6 inches wide and 2 inches high is generally made to remove objectionable bark. The broadax is held horizontally against the blaze, with the head slightly downward, by one man, while another drives it into the tree with a maul. The ax is then withdrawn and the apron inserted.

A recently introduced apron is lunar in shape, the concave edge being provided with stiff teeth. This apron can be driven directly into the tree, obviating the necessity of blazes or gashes.

The cups are made of galvanized iron or clay and hold about a quart. Their general shape is that of an oblong box 12 inches by 3 inches at the top, and about 3 inches deep. They are slightly larger at the top than at the bottom, and are sometimes shaped to conform to some extent to the curvature of the tree. The cups are sometimes hung from the apron by means of small hooks which engage an extension on either end of the apron, or they may be supported on a nail driven into the tree beneath the apron. The likelihood of the fasteners becoming clogged by gum is obviated by the use of nails as supports. In hanging this class of cups large blazes are not necessary, and if properly hung practically all the gum flowing from the tree reaches the cups. As the aprons occupy but little vertical space and the cups are comparatively shallow, a distance of 12 inches from the ground to the first streak is ample on normal trees (Plate V, fig. 1). In the case of small trees 10 inches or less in diameter, the use of the 2-piece or riveted apron allows a shallower cut to be made in hanging the cup, as the 1-piece aprons have such a large curvature that they require a deep cut in small trees (Plate VI, fig. 1) to prevent escape of gum at the sides. On large timber, of course, this difficulty does not occur.

Class 3. (Plate VII, fig. 1.) The cup is so constructed as to obviate the necessity of using a gutter or apron. In order to hang it, several

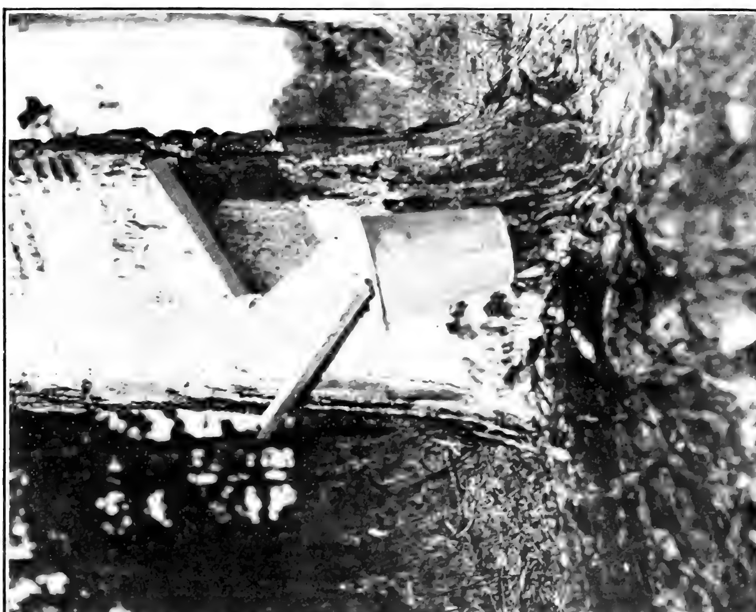


FIG. 1.—CUP AND GUTTERS.

Twenty-one inches from ground to first streak, 5 inches between gutters, 6 inches from first streak to lower end of upper gutter. Note large useless blaze 16 by 9 inches below first streak. Nine inches of chipping height have been lost.

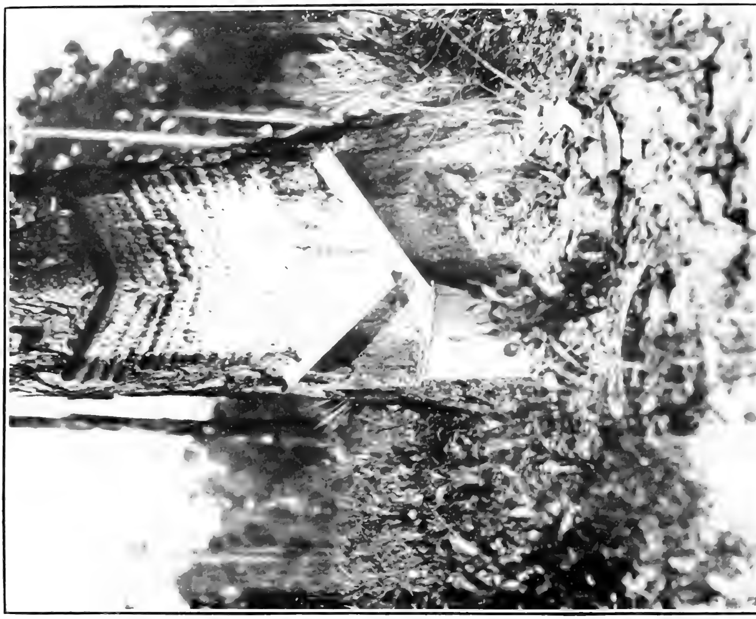


FIG. 2.—PROPERLY HUNG CUP AND GUTTERS.

Twelve inches from ground to first streak.

FIG. 1.—BADLY HUNG GUTTERS.

Twenty-nine inches from ground to first streak. Seventeen inches, or nearly a year's chipping height, has been lost.

FIG. 2.—CUP AND GUTTERS.

Lower gutter projects too far. Five inches from lower gutter to first streak.

streaks are made at the base of the tree, the last one being a "shade" streak or one which is undercut. The prolonged back of the cup is notched and bent to conform to the chipped surface. The cup is loosely hung on a nail, so as to be readily detachable for dipping. The first chipping is so made as to leave a band of bark and wood 1½ to 2 inches wide over which the resin flows and drips into the cup. The last chipping of the season should be a shade streak, so that at the beginning of the succeeding season the cup may be raised and fitted under it and a strip of bark and wood left as before.

Great care must be used in hanging these cups or the loss of resin will be excessive. It is difficult to make a shade streak close to the ground, and if a square streak is made the resin will flow between the tree and the cup. The cup in Plate VIII, figure 1, was originally hung so poorly that rehanging was necessary in the middle of the first season. The equipment for hanging cups of this class is simpler than in the case of those requiring gutters and aprons, and the necessity of gashing the tree with a broadax is obviated.

Class 4. (Plate VII, fig. 2.) Two gutters of galvanized iron are inserted in a streak just above the cup which is hung on a nail. The gutters are semicircular in section and the ends are so riveted together that the gutter may be adjusted to any angle. To hang the gutter, a shade streak is made and the gutter fitted into it and held in position by means of two nails driven through holes made for the purpose.

This gutter can be hung by one man and no special tools are required. No wounding is necessary, except a single streak; and, owing to the rivet, the gutter will serve readily for small and large timber. Unless care is used in placing these gutters, however, the gum will flow between them and the tree.

Class 5. The gum flows from two holes bored diagonally upward into the tree from a common point. The top of the receiving vessel consists of two caps at right angles, connected by a triangular tube. One cap is placed over the holes bored into the tree, while a glass cup screws into the horizontal cap. When full, the cups are unscrewed and emptied. When the flow ceases, the old holes are reamed out or new ones bored. Experiment has shown that the holes in the tree, as well as the tube in the receiving vessel, soon become plugged with gum, rendering the maintenance of a continuous flow an expensive operation. This method of tapping is worthy of mention, however, since by its means two highly desirable results in naval stores operations are obtained, namely, a pure gum and minimum damage to the timber.

Material and shape of cups.—The great majority of cups on the market are made of clay or galvanized iron. The clay ones are the cheaper, and it is claimed for them that they yield a higher quality

of gum, since clay does not become heated like metal when exposed to the sun and thus cause evaporation of the turpentine. Clay cups are three or four times as heavy as metal cups, however, and much more bulky. They are also more likely to break, both in transit and in handling. On the other hand, they do not rust like the galvanized-iron cups. Rusting not only results in loss of cups, but may also darken the gum.

In shape the cups may be like a flowerpot (Plate I, fig. 2), an oblong box (Plate V, fig. 1), or a flattened cone (Plate VII, fig. 2). With the deep cups, it is claimed, there is less evaporation of gum, on account of the smaller surface exposed. On the other hand, deep cups take up more vertical height on the tree, and are generally considered more difficult to dip. The cone-shaped cups are similar in shape to the interior of the ordinary "box," being so made for the sake of economy, since only one seam is necessary.

Within certain limitations the kind of cup used with a particular gutter or apron is immaterial. Between the cups and gutters now on the market, the greatest room for improvement exists in the case of the latter, though improved aprons and gutters are constantly put on the market.

RELATIVE YIELDS SECURED FROM CUPS AND BOXES.

Experiments made by the Forest Service in Georgia during 1902 showed conclusively that more and better turpentine and rosin can be obtained by the use of cups than by the use of boxes.

The timber studied consisted of a first, second, third, and fourth year crop, one-half of each crop being turpentined by the cup system and the other half by the box system. The comparative results are shown in Tables 9 and 10.

TABLE 9.—*Spirits of turpentine from eight half crops, season of 1902, Georgia.*

Half crops.	From dip.	From scrape.	Total.	Excess from cupped trees.	
	Gallons.	*Gallons.*	*Gallons.*	*Gallons.*	*Per cent.*
First year:					
Cups	1,385.3	205	1,590.3	301.9	23.43
Boxes	1,134.7	153.7	1,288.4		
Second year:					
Cups	1,087.2	188.2	1,275.4	66.6	5.51
Boxes	941.8	267	1,208.8		
Third year:					
Cups	726.5	113	839.5	310.1	58.58
Boxes	381.9	147.5	529.4		
Fourth year:					
Cups	687.2	101	288.2	314.2	66.29
Boxes	349.5	124.5	474		

TABLE 10.—*Net rosin sales from eight half crops, season of 1902, Georgia.*

Half crops.	From dip.	From scrape.	Total.	Excess sales from cupped trees.	
				Net.	*Per cent.*
First year:					
Cups	$401.72	$47.72	$449.44	$85.51	23.50
Boxes	328.40	35.53	363.93		
Second year:					
Cups	266.34	49.25	315.59	144.13	84.64
Boxes	104.51	66.95	171.46		
Third year:					
Cups	171.27	27.44	198.71	132.65	200.80
Boxes	39.49	26.57	66.06		
Fourth year:					
Cups	167.33	29.23	196.56	132.56	207.13
Boxes	36.09	27.91	64.00		

The first year crop mentioned in Tables 9 and 10 was worked for two years longer. The combined yields obtained for the "cupped half" and "boxed half" during the 3-year period of operation are given in Tables 11 and 12.

TABLE 11.—*Spirits of turpentine from half crops, seasons 1902–1904, Georgia.*

Year.	Cups.			Boxes.			Excess from cupped half crop.	Net price per gallon at time of operation.	Value of excess from cupped half crop.
	Dip.	Scrape.	Total.	Dip.	Scrape.	Total.			
	Gallons.	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*	*Cents.*	
First	1,385.3	205.0	1,590.3	1,134.7	153.7	1,288.4	301.9	40	$120.76
Second	1,103.5	165.0	1,268.5	705.2	226.6	931.8	336.7	45	151.52
Third	781.3	136.0	917.3	536.1	190.5	726.6	190.7	45	85.82
Total	3,270.1	506.0	3,776.1	2,376.0	570.8	2,946.8	829.3		358.10

TABLE 12.—*Net sales of rosin from half crops, seasons 1902–1904, Georgia.*

Year.	Cups.			Boxes.			Value of excess from cupped half crop.
	Dip.	Scrape.	Total.	Dip.	Scrape.	Total.	
First	$401.72	$47.72	$449.44	$328.40	$35.53	$363.93	$85.51
Second	286.88	58.24	345.12	132.42	84.08	216.50	128.62
Third	212.60	61.65	274.25	124.76	79.70	204.46	69.79
Total	901.20	167.61	1,068.81	585.58	199.31	784.89	283.92

RELATIVE AMOUNTS OF SCRAPE FORMED BY THE BOX AND CUP SYSTEMS.

The resin obtained from trees turpentined by the box method must flow an increasingly greater distance each year the tree is tapped. As a result the amount of scrape formed is proportionately increased. The proportion of scrape formed by the two systems is shown in Table 13.

TABLE 13.—*Comparison of the amount of scrape formed by the cup and box systems, season 1902, Georgia.*

Half crop.	Net weight of scrape.	Net weight of dip.	Total weight of "gum" dip and scrape.	Percentage of scrape.
	Pounds.	*Pounds.*	*Pounds.*	*Per cent.*
First year:				
Boxes	10,315	42,787	53,102	19.4
Cups	13,155	51,081	64,237	20.5
Second year:				
Boxes	17,120	35,700	52,820	32.4
Cups	12,210	42,630	54,840	22.3
Third year:				
Boxes	8,580	15,435	24,015	35.7
Cups	7,200	28,245	35,445	20.3
Fourth year:				
Boxes	7,970	14,385	22,355	35.6
Cups	6,635	25,305	31,940	20.8

Scrape is troublesome to collect, yields a low grade of resin, and gives but 11 per cent of turpentine on distillation, while gum collected by the cup system yields about 19 per cent of turpentine.

RELATIVE YIELDS FROM DIFFERENT DEPTHS AND HEIGHTS OF CHIPPING.

In the years 1905 to 1908 the Forest Service carried out experiments to determine the effect of the depth and height of chipping on the yield of resin. Four crops [1] were used in the experiment, designated A, B, C, and D, respectively.

Crop A, taken as the standard, was chipped in the ordinary way, the average depth of chipping being seven-tenths of an inch and the average height five-tenths of an inch.

Crop B was used to test the effect of shallow chipping, the average depth being four-tenths of an inch.

Crop C served to show the effect of narrow chipping, the average height being four-tenths of an inch.[2]

Crop D was turpentined with reference to the possibility of working the turpentine a second time. The present method consists in exhausting the tree within four years. This crop was chipped in the same manner as crop A, but the minimum diameter of the trees turpentined was limited to 10 inches, as compared to a minimum diameter of 6 inches in crop A; in addition the minimum diameter of the tree to bear two faces was raised from 13 inches in A to 16 inches in crop D; no tree in crop D had more than two working faces.

Table 14 shows the yields from the four crops A, B, C, and D.

[1] Crops of 8,000 faces each were used.

[2] It was intended to have the height of chip in "C" half that in "A," but in spite of close supervision the chippers cut wider than was desired.

FIG. 1.—CUP AND APRON.

Twelve inches from ground to first streak, 1½ inches from gutter to first streak, 10 inches from ground to top of cup.

FIG. 2.—CLAY CUP AND APRON.

Fourteen inches from ground to first streak, 3 inches from gutter to first streak.

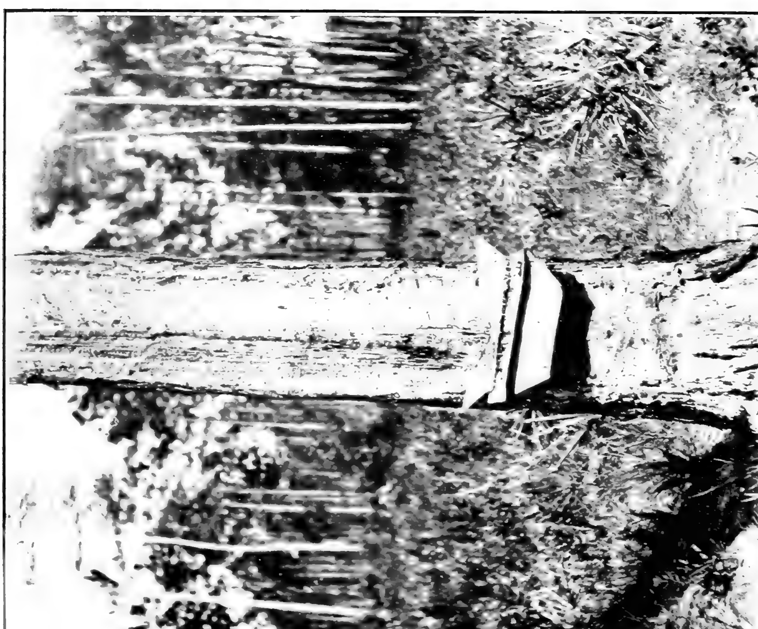


FIG. 1.—CUP AND APRON.

Working face the fourth season and the cup has been raised but once.

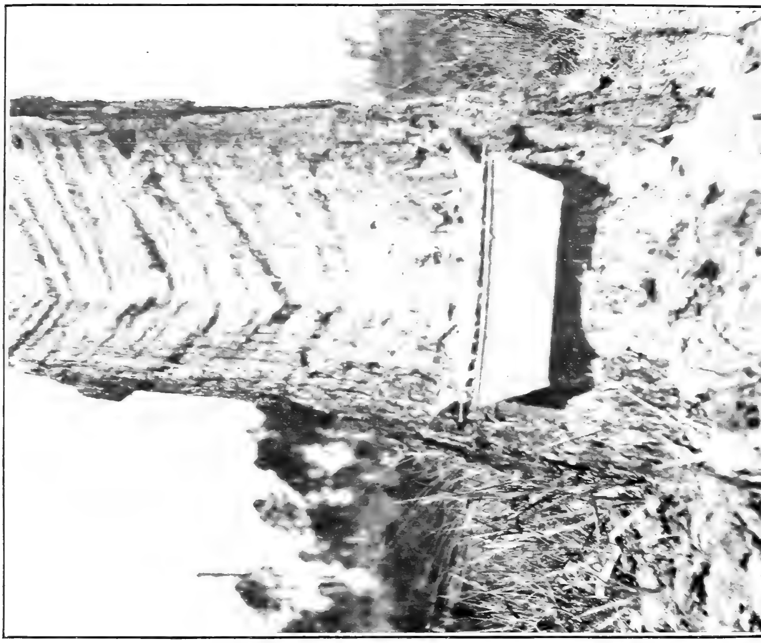


FIG. 2.—CUP AND APRON.

Working second year face without raising cup, thus reducing the efficiency of the cup system.

TABLE 14.—*Summary of total yields for four years based on the dip and scrape being corrected to the same number of chippings per crop (8,000 faces).*

Crop.	Dip.		Scrape.		
	Yield.	Increase.	Yield.	Increase.	Decrease.
	Pounds.	*Per cent.*	*Pounds.*	*Per cent.*	*Per cent.*
A	206,235		47,742		
B	211,911	2.75	44,838		6.08
C	214,503	4.01	39,775		16.69
D	279,260	35.41	53,915	12.93	

Two crops, G and H, were worked for one year, combining the principles observed under crops B and C, namely, shallow and narrow chipping. Crop X was chipped in the ordinary way. Table 15 gives the yields.

TABLE 15.—*Summary of yields for one year. Crops X, G, and H.*

Crop.	Number of cups.	Number of chippings.	Yield of dip.	Increase.
			Pounds.	*Per cent.*
X	9,880	35	90,094	
G	9,880	35	124,292	38
H	9,880	35	121,474	35

As seen from Table 15 there is a decided increase in yield by the use of shallow and narrow chipping.

EFFECT OF TURPENTINE OPERATIONS ON TIMBER.

INJURY FROM FIRE.

Since the box is rarely more than 12 inches from the ground, it is within easy reach of ground fires. As both box and face are saturated with resin, a fire once started in the box may burn the tree off at the base or render the face and box unfit to produce gum. In cupped timber the cups are moved up at the end of the season and are less exposed to fires.

Another source of fire arises from the resin which impregnates the ground at the base of the tree. Such resin may come from losses in dipping, overflow from boxes on very productive trees, or from leaning trees. This waste resin may defeat the entire purpose of raking. Spilling is less likely to occur with cups than with boxes, since the former can be detached and held directly over the bucket in dipping. By having extra cups for very productive trees the chipper who visits them weekly can quickly change the full cups for empty ones and thus prevent overflow.

The immediate danger of destruction of the timber is not so great while the trees are being turpentined as when the crop has been abandoned, since during the period of active operation the trash is raked from about the trees. Few tracts of timber escape the annual burning over, and turpentined trees are often either killed directly or permanently injured. While the damage to abandoned cupped timber is heavy, it is not so serious as in boxed timber, since the cups are removed when the trees are abandoned and the faces are the only source of fire risk.

INJURY TO GROWTH.

The box enters the tree so deeply as to injure its vitality and retard the process of growth. Boxes are generally cut in the most prominent root swellings, especially in leaning trees, as when so placed they will more readily catch the gum and are also easier to cut. The box undoubtedly curtails the food supply of the tree to a considerable extent and accounts for the fact that more "boxed" than "cupped" trees die after tapping.

The box weakens the tree so that it is liable to be blown down by the first storm. This is especially true of small timber which may have from one-half to two-thirds of its diameter severed by the box, and of timber in old orchards that has been "back-boxed," i. e., boxes cut between the old ones wherever there is available space.

The following tabulation compares the number of dead and blown-down trees in half crops worked with cups and boxes for one season:

	Trees blown down.		Trees dead.	
	Boxed.	Cupped.	Boxed.	Cupped.
After 16 chippings	5	1	2	1
After 32 chippings	8	3	35	16

Since the box fills with water after the trees are abandoned, the surrounding wood is kept moist, increasing the likelihood of attack by fungi and subsequent decay. In some cases the box is filled with earth after abandonment to prevent it from catching fire. While it may serve the latter purpose, the procedure is scarcely to be recommended, since the earth retards evaporation of the water and hastens decay.

Trees that have been "boxed" are sometimes attacked by bark-boring and wood-boring insects, the former killing the trees and the latter seriously damaging the wood.[1]

QUALITY OF LUMBER IN "TURPENTINED" AND "ROUND" TIMBER.

The wood back of the "faces" in timber that has been turpentined for several years is generally impregnated with resin for a depth of from one-half to one and one-half inches. As very resinous material

[1] See U. S. Department of Agriculture Farmers' Bulletin 476, and Yearbook 1909, pp. 410–412.

will not make high-grade lumber, the proportion of high-grade material that can be cut from "turpentined" timber is somewhat less than in the case of similar "round" timber. However, in many cases the process of squaring up the log by sawing off slabs will remove the resinous parts, and the grade of the boards finally cut will not be affected. Tests have shown that the strength of the wood is not altered by turpentining.

QUALITY OF GUM FROM BOXED AND CUPPED TIMBER.

As the height of the face increases, the distance the resin must flow to reach the box increases correspondingly. During its journey the gum is constantly losing turpentine by evaporation. Thus, the percentage of turpentine in the dip decreases each year boxed timber is tapped, while the amount of scrape increases. Cups are designed to be raised each season, and thus the gum has to flow a comparatively fhort distance.

The resin acids in the crude gum readily absorb oxygen, which darkens the rosin. The higher the face the longer the gum is subjected to atmospheric oxygen, so that, with boxed timber, light rosins can be obtained only during the first two years. Another sactor which produces dark-colored rosin is the gum that remains attached to the face after the period of collection has passed. This gum becomes yellow to dark brown, and as the following year's gum flows over it to the box, a certain amount of this highly colored product is always dissolved, so that when ordinary methods are used only the lower grades of rosin are produced from gum coming from five-year boxes. In raised cups the gum flows only over the face made during a single season. In practice, however, the cups are seldom raised after the third year, since this greatly increases the cost of collecting the gum.

COMMERCIAL DISTILLATION OF CRUDE GUM.

The apparatus commonly used in the United States for distilling gum consists of the simplest type of still, with a "worm" for condensing the vapors (Pl. VIII and fig. 5). A shed, generally open on all sides, covers the still proper, and another and smaller building, placed a short distance away as a precaution against fire, is used for storing the turpentine. It also contains the kettle for heating glue to coat the inside of the turpentine barrels. In many cases the still and warehouse are under one roof. A charging platform is built flush with the collar of the still, the barrels of gum being rolled upon it by means of skids.

The capacity of stills varies from 10 to 40 barrels. Fifteen and twenty barrel stills are the most common. The term "20-barrel still" refers to the total capacity of the still and not to the number of barrels of gum in a charge. The size of the latter is determined by

the nature of the gum; the older the gum the smaller the charge. Even with "virgin dip" the still is only filled to three-fourths of its capacity, while with dip and scrape from four or five year "boxes," which foams considerably, only about one-third the capacity of the still is used. If the material rises into the still head there is danger of it forcing an exit between collar and still head and setting fire to the platform.

The still body is about two-thirds as high as wide, with a rounded top and a slightly concave bottom, the latter permitting the rosin to

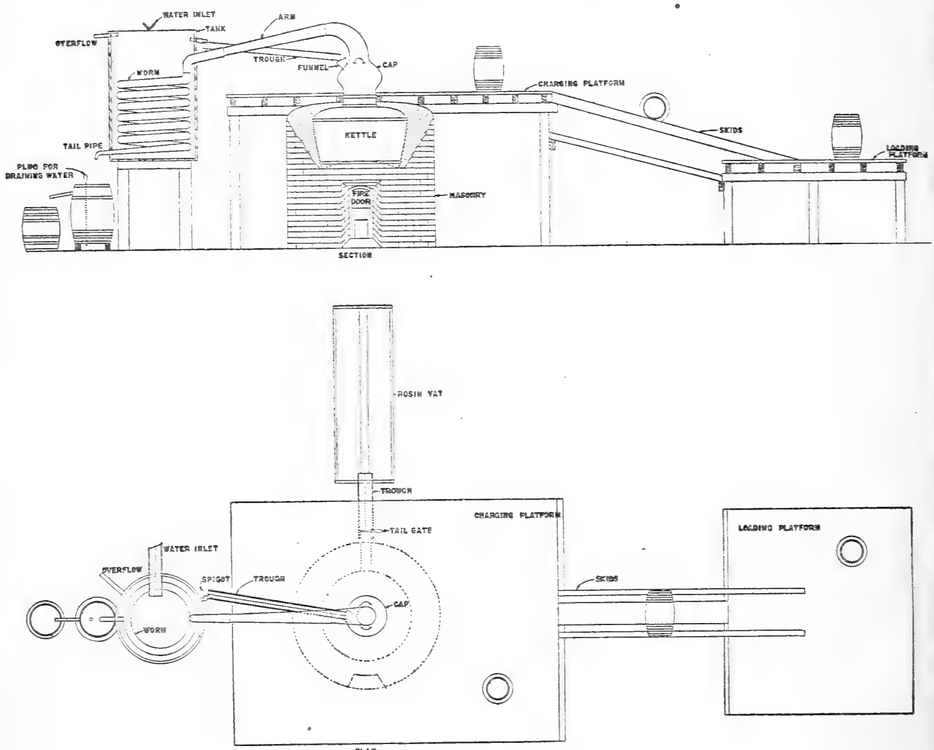


FIG. 5.—Arrangement of apparatus in turpentine still.

drain thoroughly. The still head is generally spherical[1] and is connected with the worm by two sections of pipe called the "arm" and "gooseneck." The worm makes about $6\frac{1}{2}$ turns in a wooden tank holding the condensing water, leaving the tank by means of a short pipe called the tailpiece. The entire apparatus is made of sheet copper. For a 20-barrel still, the side, top ("breast"), and collar of the still proper are made of 14-gauge copper, the rosin spout of 11-gauge, and the bottom of 4-gauge copper. The worm and connecting pipes are made of 18-gauge copper.

[1] Several forms of still head are in use.

FIG. 2.—ADJUSTABLE GUTTER.

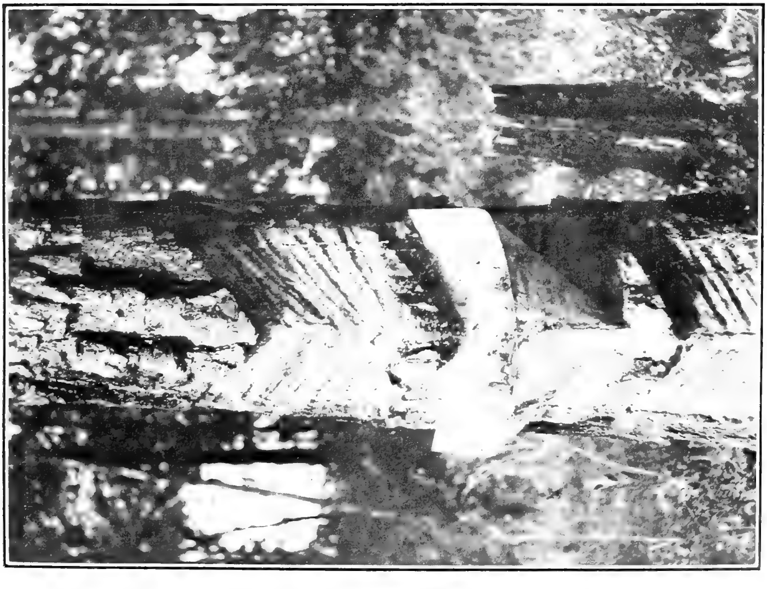
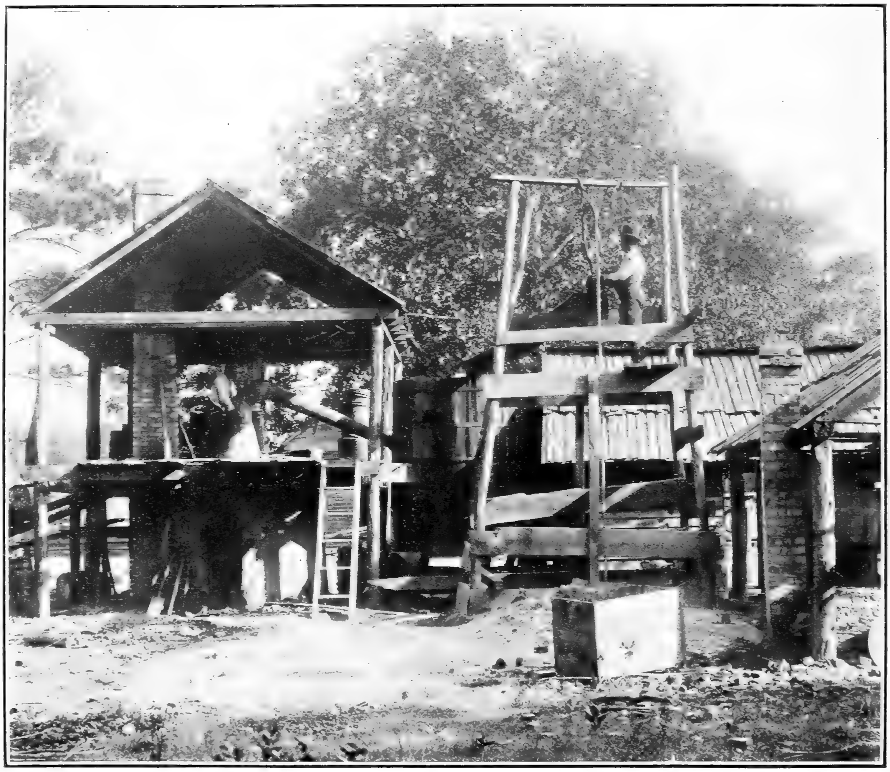


FIG. 1.—CUP WITHOUT GUTTERS OR APRON. SECOND YEAR FACE.



TURPENTINE STILL SHOWING CONDENSER.

Glue vat for coating inside of turpentine barrels on extreme right.

DISTILLATION PROCEDURE.

The still is charged by removing the still head and gooseneck and dumping in the gum from the barrels. After most of the dip has run from the barrels they are thoroughly drained over a special trough. It is hard to remove the dip from the barrels during cold weather, and distillation is not carried on extensively in winter. When scrape is distilled alone, and the still is hot from the previous run, it is customary to pour in 5 or 6 buckets of water or a couple of barrels of dip to cool off the still and prevent the first scrape put in from "burning."

After the still has been charged the cap is put on and connected with the worm by means of the gooseneck. The joints are then luted with clay. The fire is started under the still, and its intensity regulated solely by the peculiar noise made by the gum during distillation. Crude gum always contains a certain amount of water (from 5 to 10 per cent), and since the gum melts rapidly, a mixture of oil and water soon appears at the end of the worm. A distillation requires from 2 to 2½ hours; all the water originally present distills over during the first one-half to three-fourths of an hour. The "stiller" follows the course of the distillation by placing his ear near the lower end of the worm, where the characteristic sounds made by the boiling gum are most audible, and by examining portions of the distillate collected in an ordinary drinking glass and noting the proportions of water and turpentine. The point at which additional quantities of water should be added is indicated by a peculiar strident sound, characterized as the "call for water."

The water added is obtained from the top of the cooling tank. It flows from a cock, by which the size of the stream is regulated, by way of a trough into the still through a funnel placed in an opening in the cap. The water at the top of the tank is always warm, and often very hot. Some distillers obtain this water from the bottom of the tank, claiming that the distillation is easier to regulate with cold water. About 2½ barrels of water are run in for each distillation, the amount varying with the size of the charge.

The critical period during distillation is passed when all the water in the gum has been driven over, since as the water is vaporized it swells the viscous gum to such an extent that it may overflow into the worm or escape through the joints, provided sufficient space has not been left in the still for this expansion. "Dip" and "scrape" from high faces are especially likely to boil over. The tendency to foam over is indicated by the sound of tumultuous boiling at the end of the worm. When this occurs the fire is urged as rapidly as possible, the resinous chips obtained by skimming the gum usually being added, and the increased temperature maintained until the

gum returns to a normal state of distillation. The heat is increased because at the temperature at which the water is vaporized, the gum is still in a viscous condition, and is so tenacious as to form a mass of bubbles whose shells are not ruptured by the inclosed steam; hence the gum swells enormously. In order to remove this water, it is necessary to heat the gum to so fluid a state that the bubbles will burst readily and allow the steam to escape. After this inclosed water has been driven off the distillation usually runs along smoothly, since the water that is added merely comes in contact with the surface of the gum. If excessive foaming takes place after the stream of water has been started, the fire is urged as usual, but the flow of water is not diminished. If the gum should boil over the distillation is spoiled, and must be repeated.

The end of the distillation is reached when a portion of the distillate collected in the test glass shows only a very small proportion of turpentine. All the turpentine is seldom removed, if the distiller wishes to obtain a high-grade rosin. The stream of water is now cut off, and the fire extinguished with water to prevent the rosin from igniting when it is run out, and to prevent scorching the small amount of rosin that always adheres to the bottom of the still.

Skimming.—The gum always contains more or less trash, such as sand, chips, needles, pieces of bark, etc. This all goes into the still along with the gum, and is removed at various stages during the distillation. The chips are removed with a skimmer, 16 inches long by 14 inches wide, made of wire netting and attached to a long handle.

Except in the case of dip collected at the end of the season, skimming is done as soon as the charge is fluid. In other cases skimming is done either at the point when the water originally present in the gum has passed over, or at the end of the distillation when the rosin is ready to be run off. When the gum contains a considerable amount of trash, especially bark and needles, a lighter resin will be obtained by skimming before distillation. However, in the case of "old stuff," there is considerable difficulty in getting the charge fluid enough for skimming without excessive loss of turpentine and the danger of foaming.

TREATMENT OF THE ROSIN.

After the distillation is ended, the rosin, at a temperature of 302° to 392° F., is run out by means of a pipe extending flush from the bottom of the still and closed by a gate valve. Usually the rosin flows through a set of four screens into a vat sunk into the ground. One, two, or three screens may be used, however, instead of four. The vat is about 4 by 15 feet at the bottom, 4½ by 15 feet at the top, and 2½ feet deep. The screens are sufficiently large to cover it, with the exception of the top one, which is only half the length of the still, and is intended to catch only the coarsest chips. The top screen is

from 6 to 8 mesh, the second 14 mesh, the third 32 mesh, and the bottom 60 mesh. The bottom screen is covered with a layer of cotton batting to remove the finer particles of dirt.

The rosin remains in the vat from a few minutes to an hour, according to the temperature at which it left the still. It is next dipped into crude barrels made on the spot, holding about 450 pounds net. If dipped while too hot and fluid, considerable leakage occurs between the staves, which may in a measure be prevented by luting with clay. The rosin requires about 24 hours to become solid.

The cotton batting, after being used to strain the rosin, is known as "batting dross" or "rosin dross." As cotton is very absorptive, a large amount of rosin is retained. Recent analyses made by the Forest Service indicated that rosin dross contains from 75 to 90 per cent by weight of rosin.

It has been the practice to burn under the still a certain portion of the chips removed by skimming and in the screens, and to throw away the rest. In this way, piles of discarded chips often grew to large size before the stills were moved. Such piles, of course, contain considerable rosin, and during 1911 and 1912, owing to the high price of naval stores, operators found it profitable to sell not only the dross, but the skimmings and similar material to extraction plants.

TREATMENT OF THE TURPENTINE.

The distillate issuing from the worm, and consisting of a mixture of water and turpentine, runs into an ordinary 50-gallon barrel, where the separation of the water and turpentine takes place by gravity; the turpentine, being lighter, floats on the top. The bottom of this barrel contains an opening, closed with a long wooden plug, by which the excess water is allowed to escape as the volume of the distillate increases. In most cases a second container, consisting of a barrel whose upper half has been sawed off, receives the turpentine flowing from the top of the first barrel through a short pipe, to permit of more perfect separation. A thin yellow scum forms the line of demarcation between the water and turpentine. The latter is dipped out carefully and poured directly into the barrels in which it is sent to market.

The first runnings of turpentine are colored more or less green with copper salts, due to the action of acetic and resin acids on the copper of the worm and still. The green color is especially noticeable when the still is first used after a period of idleness. When the still is in continuous use the color in the first runnings is very slight.

The turpentine barrels must be thoroughly tight. They are usually made of sound white oak, thoroughly driven, and coated on the inside with glue. Each barrel holds about 50 gallons, some space being left for expansion of the contents.

FRENCH METHODS OF COLLECTING GUM.

MANAGEMENT OF FORESTS.

A large proportion of the French forests exploited for resin are situated along the coast, where the shifting sand dunes have been planted with maritime pine (*Pinus maritima*).

The forest rotation varies from 60 to 75 years, and since maritime pine is a prolific seeder, a new growth readily springs up on cut-over areas. At the end of 10 years the stand is thinned, and thereafter at 5-year intervals. During the first thinning the lower branches of the trees that are left are lopped off to a height sufficient to insure a clean bole for turpentining during subsequent years. The wood and resin rights are sold for a period of five years, the turpentining being done by the purchaser, who, at the end of the operation, fells those trees marked for thinning.

The wood is used for mine timbers, boxes, crossties, telegraph poles, etc. Turpentined timber is preferred over unturpentined, since it is very resinous and so resists decay for a longer time. The last thinning is made when the trees are about 30 years old, and the remaining pines, numbering about 50 per acre, are then turpentined. At the end of the rotation period, owing to various casualties, there remain only about 30 trees per acre for lumbering.

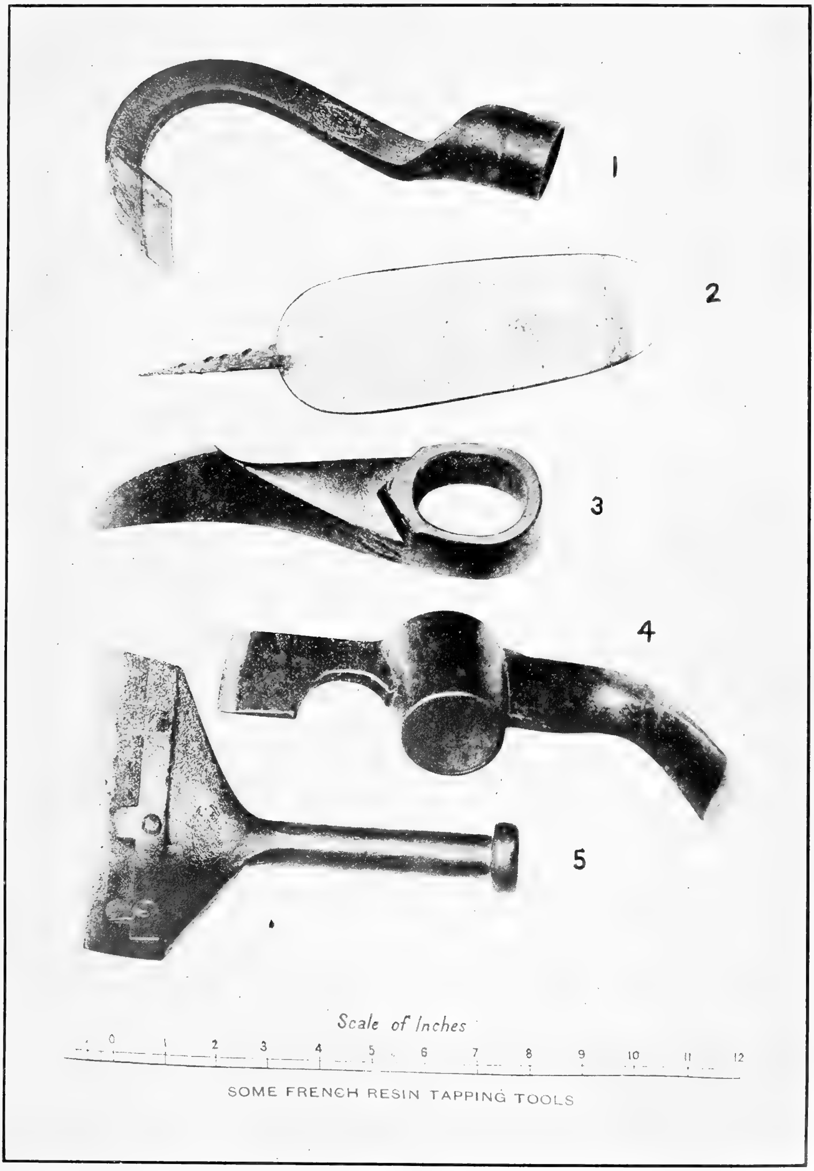
Up to the year 1860, practically all resin was collected in holes scooped out of the sand at the base of the trees. This method was wasteful, and the gum was badly contaminated with sand and other débris. The use of an earthen pot with a gutter was suggested in 1840 by M. Hugues, of Tarnos, but was not taken up until 1860. At present the Hugues cup and gutter system has almost entirely superseded the old method.

BARKING.

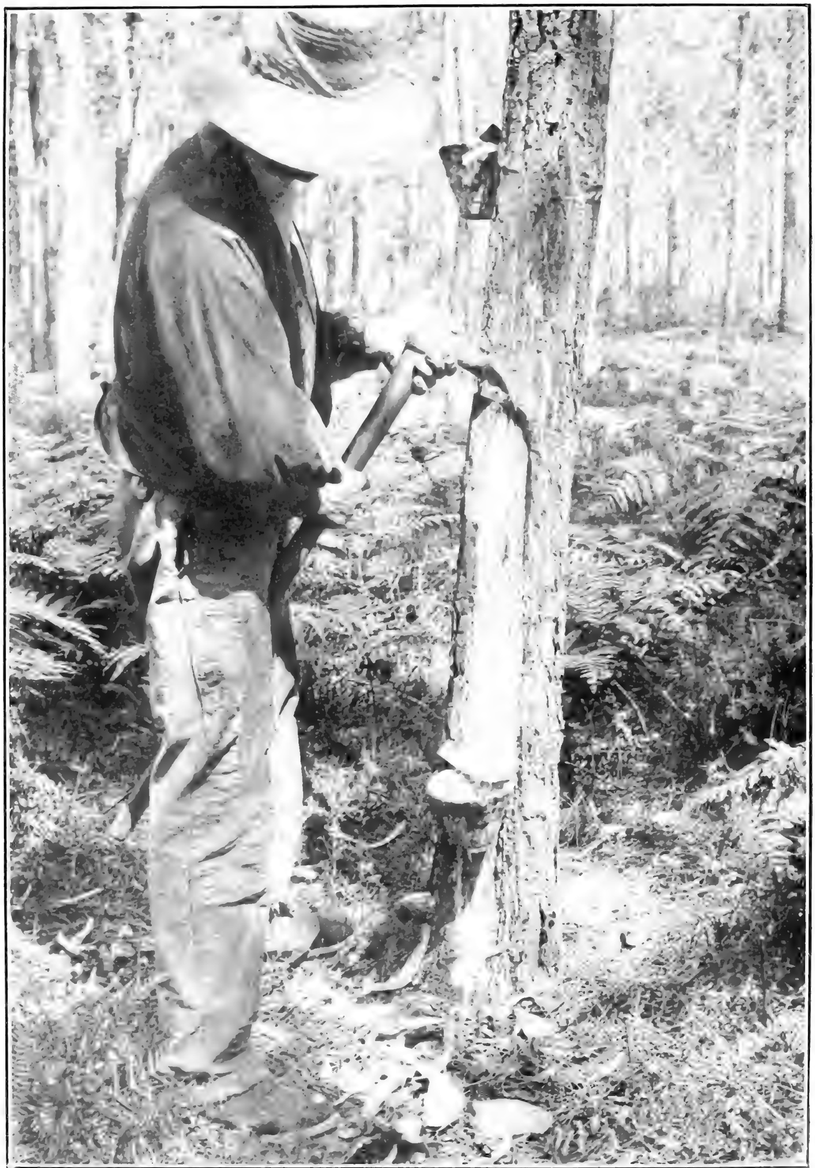
Before the turpentining season opens the outer bark is removed over an area exceeding somewhat the area to be chipped during the coming season. The denuded area measures 24 inches in height and 6 to 8 inches in width, and in depth reaches to the living layer of the bark. The operation is performed carefully with a wide-bladed ax. Above the height of a man the ax is replaced by a tool with a hook-shaped blade, 3 inches wide, attached to a long handle, which is wielded with a pulling motion. The bark is removed to prevent dulling the delicate edge of the chipping tools, and the rays of the sun on the exposed area are supposed to have a beneficial effect in stimulating the flow of resin.

HANGING CUPS (HUGUES SYSTEM).

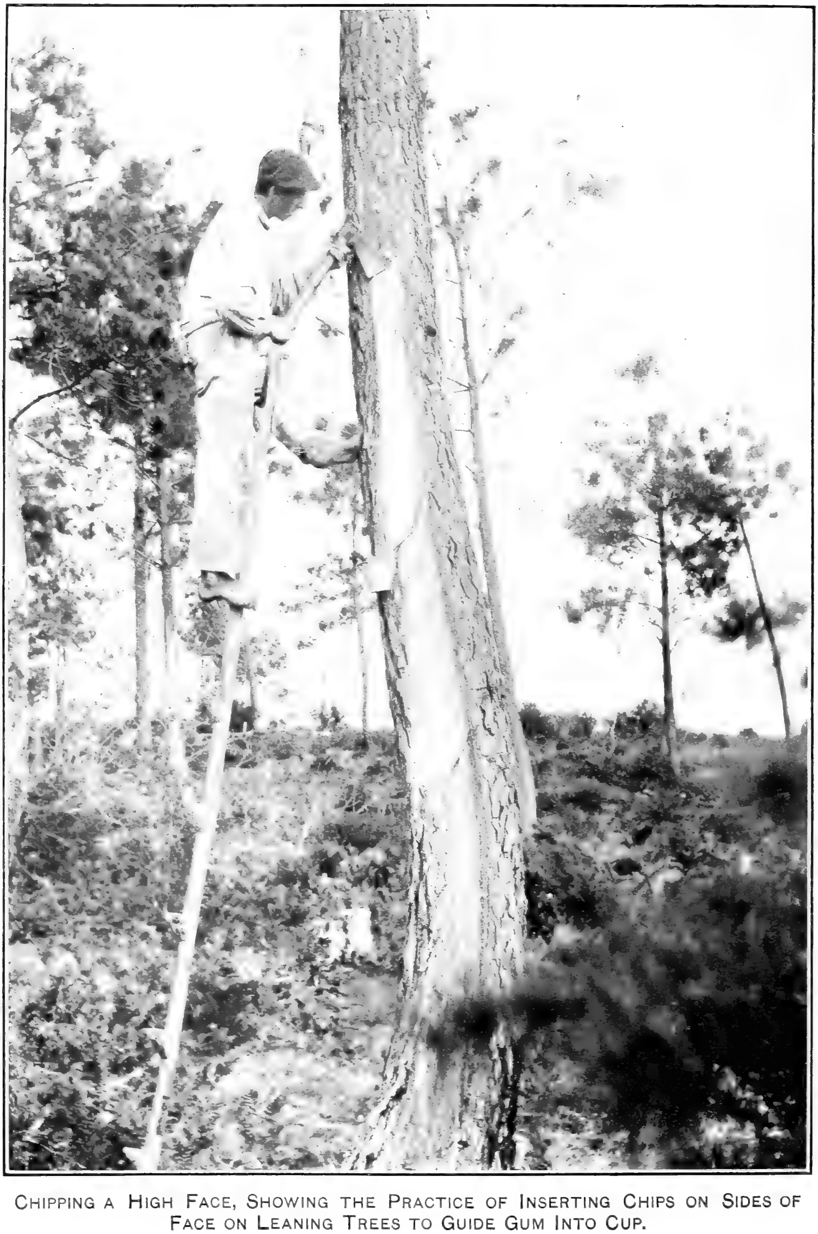
The face is opened the first of March by removing a chip 1.6 inches high, 3.5 inches wide, and 0.4 inch deep from near the base of the tree. The tool used is a peculiarly shaped instrument called the "abschot" (Plate IX–3). A zinc gutter is inserted at the base of the wound in a



FRENCH TURPENTINE TOOLS.



CHIPPING A LOW FACE, SHOWING THE SHAPE OF THE AXE AND RELATIVE SIZE OF THE FACE.



CHIPPING A HIGH FACE, SHOWING THE PRACTICE OF INSERTING CHIPS ON SIDES OF FACE ON LEANING TREES TO GUIDE GUM INTO CUP.

gash made by a chisel (Plate IX–5) with a cutting edge in the shape of the arc of a circle. Below the cutting edge is a socket into which the gutter fits. The gutters are 8 inches long and 2 inches wide, and in some cases are provided with five teeth. A gash 0.2 inch deep has been found sufficient to hold the gutters, since the resin soon enters the wound and acts as a cement.

The pots used are made of glazed earthenware, conical in shape, 4½ inches wide at the top, 3 inches at the bottom, 6 inches high, with a capacity of about 1 quart (1 liter). The cup rests on the ground the first year, and is raised along with the gutter at the beginning of each succeeding year of operation. The upper part of the pot is held in place by the gutter, which projects out and downward, while the base rests on a nail driven into the tree. The top of the cup is never provided with a hole for hanging on a nail.

CHIPPING.

Chipping is begun about the first of March and ends the latter part of October. A total of 40 chippings is usually made in one season.

The chipping tool (abschot) is of two types: One type is a combined adz and gouge, the blade hanging at right angles to the handle, its edge shaped like the arc of a circle. In the other type the blade is parallel to the handle, but bent outward so that the cutting edge does not fall within the plane of the handle.

In using the abschot the workman stands to one side and in front of the face, with the handle between his legs (Plate X). In removing the chip the blade is inserted at the extreme upper corner of the face and is drawn diagonally toward the workman. Little effort but great skill is required.

The wood removed in chipping is in the form of shavings, so that the edges of the face are perfectly smooth, allowing the wound to heal rapidly. The face increases in height about 0.6 inch at each chipping. After the face is opened, chipping is repeated every 8 days from March to May, every 5 days from June to the end of August, and every 8 days from September to the middle of October or the first of November.

After the face has reached the height of a man the abschot is discarded for the rasclet. The rasclet (Plate IX–4) has a hook-shaped blade, with its edge at right angles to the long handle, and the chip is removed by a pulling motion. In the case of leaning pines, wooden chips are inserted along the edge of the face to guide the resin toward the pot (Plate XI).

The dimensions of the faces must conform to the tapping specification, and frequent inspection is made by government officials to see that these are carried out. Since the wages of the workman consist of half the proceeds from the sale of the resin, he naturally wishes to collect as much resin as possible, and is tempted to increase the size

of the face beyond the prescribed limits. An instrument devised by Demorlaine in 1898, called the "facemeter" (quarrimetre), permits of a ready and accurate measurement of the face.

SYSTEMS OF TURPENTINING.

Two systems of turpentining are employed, "gemmage a vie" and "gemmage a mort." "Gemmage a vie" is the system used when the tree is to be moderately turpentined for a long period of years; "gemmage a mort" when the trees marked for thinning or final felling are to be made to yield the greatest possible amount of resin in five years without actually being killed.

The following articles are taken from the turpentining specifications issued by the French Government in 1909:

Gemmage a vie.—The tapping will take place on either one or two faces, according to the indications of the Service des Eaux et Forets. Only those trees can be tapped with two faces which have been designated for this purpose.

The faces will be started above the swelling of the root and raised either vertically or in accordance with the grain of the wood.

If the tapping period is for five years, the face can be raised 0.60 m. (24 inches) during the first year and 0.65 m. (26 inches) during the following years in such a manner that the total height does not exceed 3.2 m. (10 feet 6 inches).

If the tapping period is for four years the face can be raised 0.60 m. (24 inches) during the first year; 0.65 m. (26 inches) during the second; 0.85 (33 inches) during the third, and 1 m. (3 feet 3 inches), in such a manner that the total height does not exceed 3.1 m. (10 feet 2 inches).

In every case the width of the faces should not exceed 0.09 m. (3.5 inches) the first year, 0.08 m. (3.1 inches) the second, 0.07 m. (2.8 inches) the third, and 0.06 m. (2.4 inches) at the beginning of the fourth.

The decrease in width should take place progressively in such a manner that the width of the face at the end of one year shall be that at the beginning of the year following.

The depth should not exceed 0.01 m. (0.4 inch), the measure being taken under a cord stretched from one border of the face to the other, at the beginning of the red part of the bark.

The tapping will take place according to the directions of the Service des Eaux et Forets; either by fours (au quart), the faces up to the fourth inclusive being made, as far as possible, two by two at the extremities of the same diameter; or by threes (au tiers), the faces up to the third inclusive being made by dividing the circumference of the tree into three nearly equal parts; the second should be opened at the right of the first when facing the latter.

In case of the absence of directions in the contract the tapping will be done by fours.

Gemmage a mort.—If the trees to be tapped *á mort* form part of the sale or are abandoned to the lessors, the latter can work them as they think best.

In the contrary case the lessors should not tap them in a manner to diminish the value which they should have as fuel and structural timber. The dimensions of the face should be such that its whole area never exceeds the limits of an ordinary face.

The tapping operation will be confined between March 1 and October 31 of each year, but the contractor can commence to bark the pines which are to be tapped and place the gutters February 1.

He can also collect the scrape up to December 1 of each year of the tapping period, except the last year, when this operation should be ended the 15th of November.

Two kinds of scrape are distinguished in France. The hardest kind adhering firmly to the face is called "barras," while the soft scrape is called "galipot." The tool used (Plate IX–1) for removing the scrape resembles that used in removing the outer bark, except that the blade is only 1½ inches wide. Usually the trees are scraped but once a season, in November, but sometimes an additional scraping is made in June.

The method of collecting the crude gum is practically identical with that used in America.[1] The resin is temporarily stored in wooden tanks sunk into the ground at convenient points in the forest until it is ready to be transported to the still.

FRENCH DISTILLATION METHODS.

In French operations the barrels of resin as they come from the forest are usually stored in large tanks, so as to form a reserve supply to be worked up during the winter months when no resin is collected. The storage tanks are sunk into the ground at a distance of 75 feet from the still, and the resin transferred to the latter by means of an overhead trolley. The tanks are built of brick or cement and covered with tile.

PURIFICATION OF THE RESIN.

The resin is often subjected to preliminary treatment previous to distillation to remove the trash. This is not done, however, unless high grade rosin can be produced which will bring a good price, since the process results in loss of turpentine and requires extra fuel and labor.

The preliminary treatment involves fusion, clarification, decantation, and straining. The fusion is performed in open or closed pans.

Open pans.—The resin is liquified in a cylindrical copper pan 6 feet in diameter and 1½ feet in depth, with a slightly concave bottom.

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[1] Comparison of yields of crude gum per inch of width of face, French and American methods:

Data from French operations indicate an average yield of 1.8 liters of crude gum per face per year, or 4 pounds.

If chipped 40 times yield per face per chipping=0.1 pound.
If face is 3.5 inches wide yield per inch width=0.029 pound.
If face is 4.0 inches wide yield per inch width=0.025 pound.

Data from American operations:

Crop A—8,000 faces. (See page 25):
206,235 pounds gum in 4 years=6.4 pounds per face per year.
43,633 pounds scrape in 4 years=1.4 pounds per face per year.

Total.................... 7.8

If chipped 32 times yield per face per chipping=0.244 pound.
If face is 12 inches wide yield per inch width=0.020 pound.
If face is 14 inches wide yield per inch width=0.017 pound.

Crop D—8,000 faces. (See page 25):
279,260 pounds gum in 4 years=8.7 pounds per face per year.
53,915 pounds scrape in 4 years=1.7 pounds per face per year.

Total 10.4

If chipped 32 times yield per face per chipping=0.325 pound.
If face is 12 inches wide yield per inch width=0.027 pound.
If face is 14 inches wide yield per inch width=0.025 pound.

This pan, inclosed by brickwork and heated by the flames from a fire-box, has a capacity of about 325 gallons.

After the pan has been filled with crude resin the heating is conducted very slowly to prevent "burning." A workman stirs the mass constantly with a wooden paddle to render the heating uniform. When boiling begins the heating is discontinued, as the temperature should never be allowed to exceed 90° to 100° C. To clarify the mass the temperature is suddenly reduced by drawing the fire. Sometimes a small amount of water is thrown into the fire box and upon the bottom of the pan. If this delicate operation is successful, the mass will settle into several layers after standing for four or five hours. A layer of chips, bark, etc., will be found on the surface; then a layer of resin; and below this a layer of colored water with a deposit of sand, etc., on the bottom. The floating chips and bark are removed by skimming. The resin may then be run out through pipes arranged at different levels, but usually is dipped out. The heaviest material is filtered through a screen to remove the sand, the filtrate separating into a layer of colored water surmounted by a small amount of inferior resin. By this procedure a resin is obtained which on distillation will yield a rosin several grades higher than the original resin would give if distilled with all its impurities.

Purification in an open pan results in the loss of from 2 to 3 per cent of turpentine, and there is considerable danger of fire. Several pans provided with covers have been designed to overcome the objections cited.

Closed pans.—The pan designed by Dromart (fig. 6) illustrates the closed type. It is provided with a horizontal cover whose edge fits into the groove (R), the latter being fed by a stream of cold water so that the cover is hermetically sealed. The pan is charged without loss of turpentine by means of a box (B) with a trap in the bottom worked by a lever. By manipulating this lever the resin contained in the box falls into the pan. To obtain uniform heating the resin is stirred by means of an agitator (G). At the end of 4 to 5 hours the melted resin shows a temperature of from 85° to 90° C., and a jet of steam issues from a test hole in the cover. The heat is then reduced, and the liquid mass cooled by dumping in one or two boxes of resin through the trap. After stirring vigorously the mass is allowed to rest for 12 hours. The resin is then decanted through a pipe (V) situated above the bottom so as to keep the layer of water and dirt below its orifice.

It is sometimes difficult to separate the water and solid impurities from the resin, owing to the fact that the density of the resin and that of the water are so nearly the same. The density of a gum containing 80 per cent rosin and 20 per cent turpentine, at 20° C., is about 1.023, while at the same temperature distilled water has a density of 0.998. Since the water in the resin contains certain amounts

of dissolved matter, its density may be greater than the figure given, while the density of resin richer in turpentine will be less than 1.023. To separate the two it is necessary to lower the density of the resin or increase the density of the water. The former is accomplished by adding certain amounts of "heads" and "tails" from a previous dis-

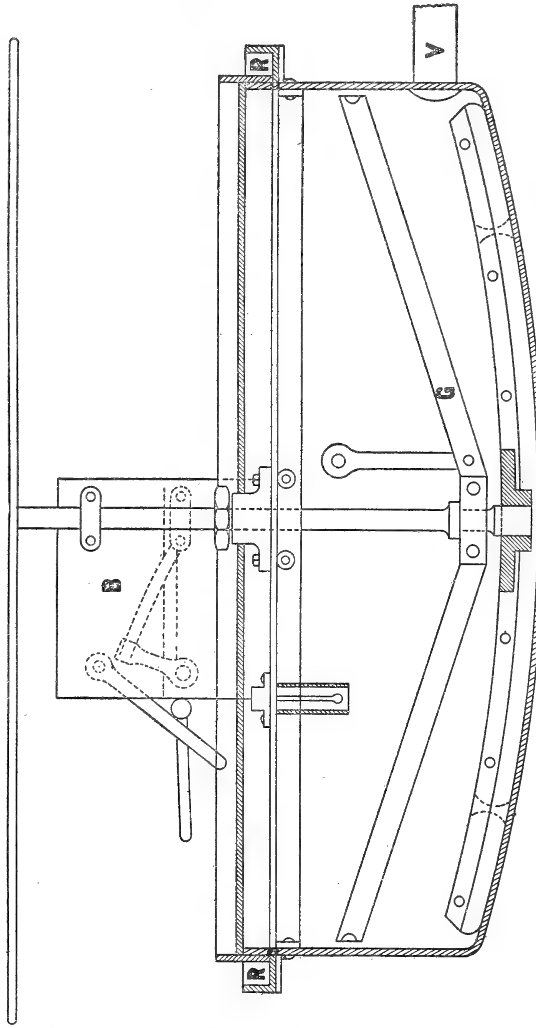

FIG. 6.—Tye of closed evaporating pan used in France to prevent loss of turpentine when gum is purified.

tillation, and the latter by adding a cheap salt, such as common salt or soda.

DISTILLATION BY DIRECT HEAT.

Direct heating is the method of distillation generally employed in France. The type of still and its method of operation are exactly the same as in the United States.

DISTILLATION BY STEAM.

Of the 200 stills producing turpentine and rosin in France, only about 30 use steam. Several types of steam apparatus are employed, but the Dorian still will serve as an example of the stills heated by steam only.

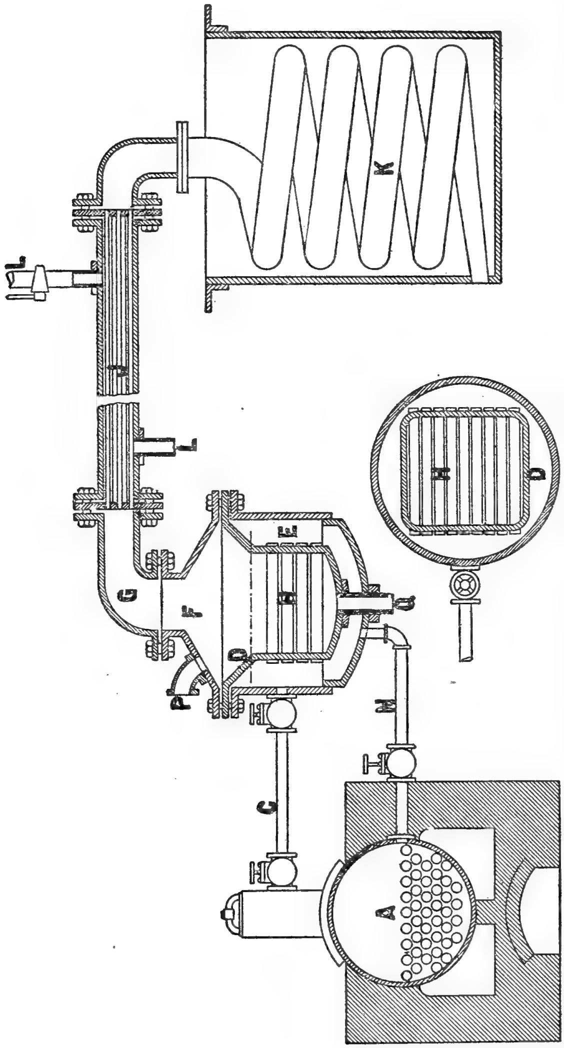

FIG. 7.—Type of steam turpentine still used in France.

This still is remarkable in its simplicity, compactness, and efficiency. Its principal advantage lies in the fuel economy obtained by returning directly to the boiler the condensed water obtained from the steam used in heating the still, instead of allowing it to flow away as a complete loss or running it into a tank for feeding the boilers.

The apparatus (fig. 7) consists of a steam generator, still, and condenser. The generator A, which may be of any type, feeds the

still by a pipe C attached to the steam dome. The still is constructed entirely of steel made to stand a pressure of 10 atmospheres, although 6 atmospheres is never exceeded in actual practice. The still consists of a gate valve P for introducing the crude resin and another gate valve Q for discharging the rosin; the body of still D, shaped like a prism; a steel jacket E, circular in shape; 32 tubes H, arranged crosswise in four series of eight tubes each, running through the still from one side to the other, through which passes steam from the jacket E; a hood F; a still-head G; and a pipe N, which leads back to the boiler the water produced by condensation of steam in the still. Since the pressure in the boiler and in the steam jacket is the same, this condensed water readily returns to the boiler by its own gravity.

The crude resin, divided into thin layers by the pipes H, distills rapidly. To carry the turpentine over, water is supplied through a funnel in the top of the hood F.

The condensing apparatus consists of a tubular condenser J and an ordinary worm K. The condenser is made up of a series of tubes from 10 to 12 feet long, riveted to two steel plates, and is fed with cold water through LL′. The tubular condenser is so efficient that the worm becomes almost useless.

A still having a capacity of 92 gallons (about 2 barrels) has a heating surface amounting to about 120 square feet, and permits the distillation of one charge in about 40 minutes.

When the turpentine is completely removed the introduction of water ceases. The heating is continued by means of the steam jacket until the rosin is free from water.

COMPARISON BETWEEN DIRECT AND STEAM HEATED STILLS.

The disadvantages of distilling with directly heated stills may be summarized as follows:

1. During the distillation of the crude resin the ligneous impurities may undergo a partial carbonization which colors the rosin.
2. The rosin becomes exceedingly dark at high temperatures.
3. The rosin may undergo incipient decomposition and color the turpentine more or less yellow.
4. Distillation by direct heat is a delicate operation, difficult to regulate, and requiring an experienced man. It can be applied only to a comparatively small quantity of material, if good results are to be obtained.
5. Increased fire risk.

By using stills heated by steam the above disadvantages are removed, but others are introduced. The reasons why the use of steam stills has not become general are:

1. Complicated apparatus.
2. Greatly increased cost of apparatus and expense of operation.
3. Necessity for a large stock of crude resin, if the still is to be operated economically.
4. With the majority of apparatus the crude resin must be given a preliminary treatment to remove chips, bark, sand, and other trash.

5. Only a slight increase in the commercial value of the turpentine and sometimes of the rosin.[1]

However, when fuel and crude resin are plentiful, steam stills have the following important advantages:

1. Very pure turpentine, better than that obtained by direct heat.
2. Rosin not superheated, and but slightly colored.
3. Simple and easy control of the distillation.
4. Decrease of fire risk.

As a general rule, an experienced distiller will obtain as good results with the ordinary American still as with a steam still.

THE SUPPLY OF LONGLEAF PINE FOR TURPENTINE OPERATIONS.

Up to the middle nineties the large supply of yellow pine stumpage, the prejudice against lumber cut from turpentined trees, and the lack of adequate transportation facilities in many regions where turpentine operations were conducted, caused large bodies of turpentined timber to be abandoned and left to be destroyed by fire, wind, and decay. It is estimated that in each of the States of North Carolina, South Carolina, Georgia, Florida, Alabama, and Mississippi the loss in boxed timber has amounted to from three to ten billion board feet.

At present the damage to standing timber due to turpentine operations has been considerably reduced. The cup systems lessen the fire risk and the heavy demand for lumber, coupled with improved transportation facilities, has shortened the period between the end of turpentine operations and the beginning of lumbering. However, as the supply of timber available for turpentining has grown smaller, the practice of turpentining undersized trees has become common, especially in second-growth stands that have come up after old lumber operations. When a tree under 6 inches in diameter is boxed it seldom makes further growth, and cupping has almost as bad an effect. Not only is further growth prevented, but the tree becomes a menace to the rest of the stand through windfall, fire, or decay. The future production of naval stores in the Southeast is rendered uncertain by the practice of turpentining small trees, and the future supply of longleaf pine is endangered. Moreover, the returns derived from turpentining small timber are, as a rule, hardly sufficient to cover the expense of operation.

The scarcity of longleaf pine suitable for turpentining has reached an acute stage in North Carolina, South Carolina, and Georgia, and is the natural result of the exhaustion of the virgin pine forests. While considerable "round" timber—that is, timber which has never been tapped—remains in Alabama, Mississippi, Louisiana, and Texas, it is

[1] On Apr. 5, 1911, the quotation at Savannah on "B" rosin, the lowest grade, was $8.15 per barrel, while "WW," or the highest grade, brought but $8.62 per barrel. The average price of "WW" rosin during the naval stores year 1913–14, was $6.38, and of "B" rosin, $3.96 per barrel.

for the most part held by large lumber syndicates, which usually are unwilling to permit turpentine operations. A few of the holding companies are beginning to permit turpentining, either carrying on the operations themselves or leasing the privileges to large naval stores companies. In Florida the small operator has more oppor-

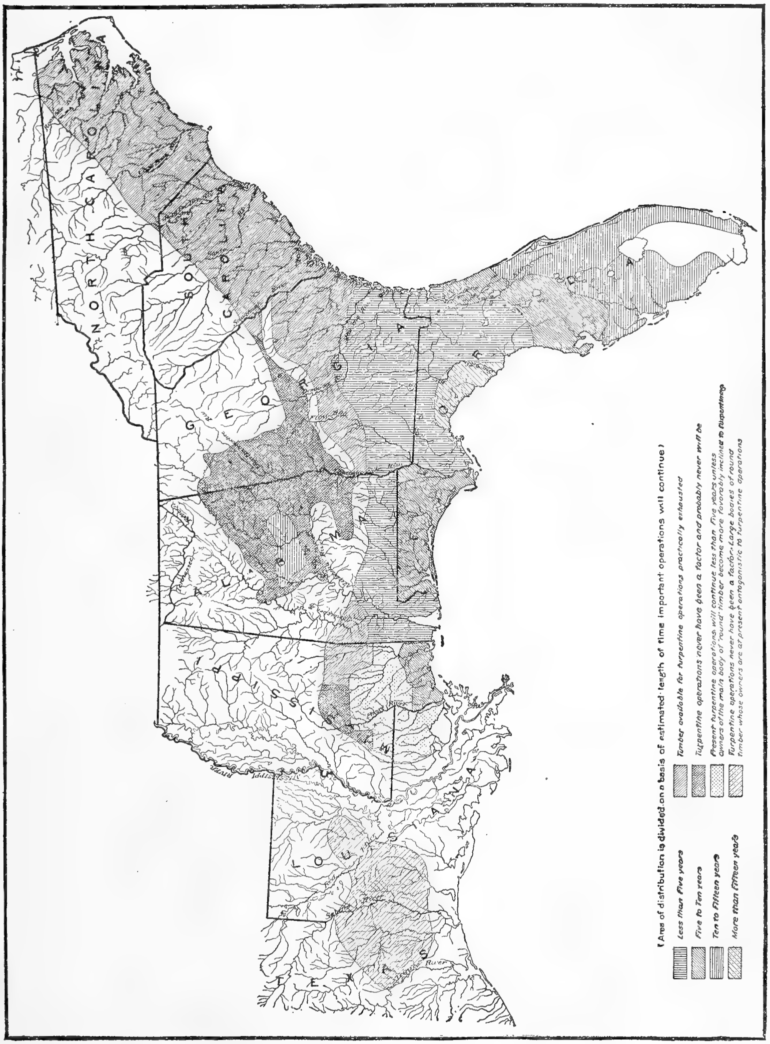

FIG. 8.—Approximate distribution of longleaf pine with reference to turpentine operations.

tunity, since much of the timber is at present in the hands of turpentine men.

Figure 8[1] shows the distribution of longleaf pine. The various styles of crosshatching denote the estimated number of years (from 1909) for which virgin timber will be available for turpentine opera-

[1] Taken from unpublished report, "Investigation of the Naval Stores Industry," by A. L. Brower and J. D. La Fontissee (1909).

tions. By this it is not meant that production will cease in any given region within the time indicated on the map, but that after the lapse of such time it is probable that the turpentine operator will have to make use of second-growth timber and that left by the lumberman. Under these conditions the production will amount to but a fraction of the present production. This prediction is based on the supply of

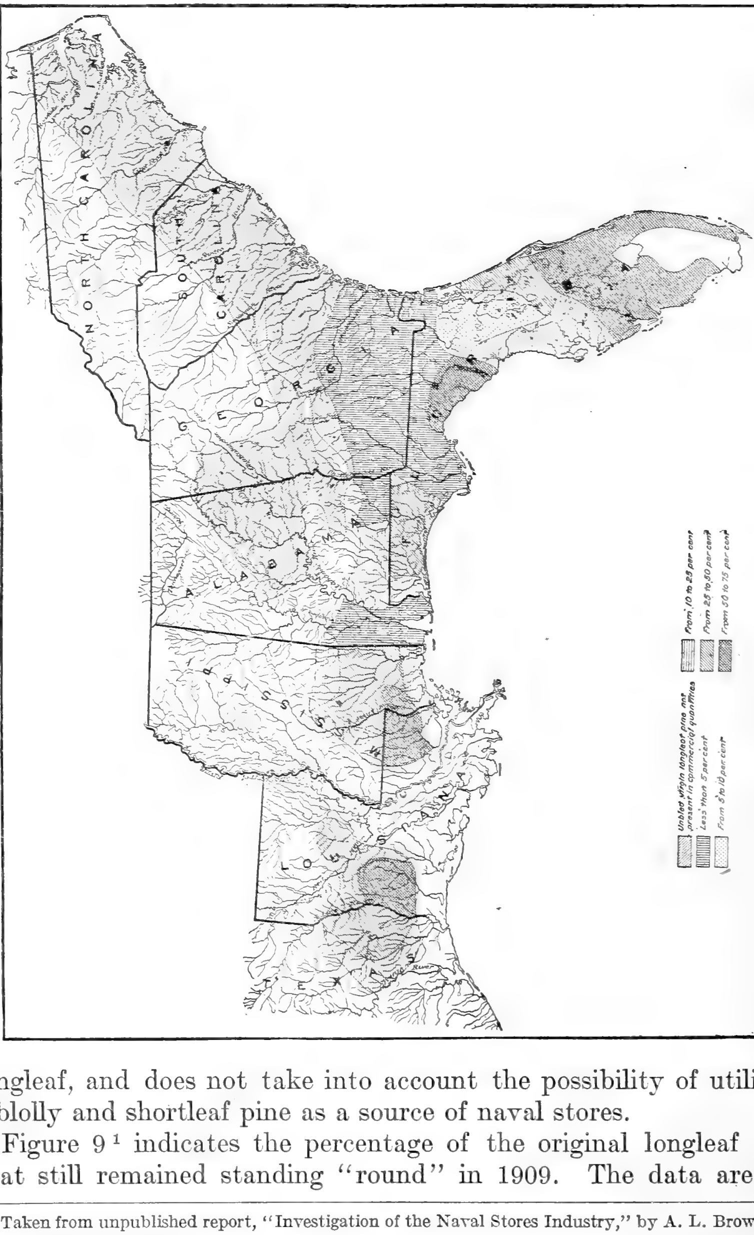

FIG. 9.—Approximate distribution of longleaf pine with reference to percentage of original stand remaining unbled.

longleaf, and does not take into account the possibility of utilizing loblolly and shortleaf pine as a source of naval stores.

Figure 9[1] indicates the percentage of the original longleaf pine that still remained standing "round" in 1909. The data are not

[1] Taken from unpublished report, "Investigation of the Naval Stores Industry," by A. L. Brower and J. D. La Fontissee (1909).

intended to be accurate for any particular locality, but rather to represent as correctly as possible the conditions generally obtaining over the territory, the unit of consideration seldom being less than a county. The high price of naval stores in 1911 produced an unprecedented invasion of the "round" timber. It has been estimated that 75 per cent of the "round" timber held by turpentine operators was tapped in 1912.

YIELDS PER CROP IN VARIOUS STATES.

Table 16 shows the yield per crop in six States in the turpentine belt and the percentage of gum secured by boxing and cupping. It is noticeable that the States in which the yield per crop was largest also made the largest use of improved methods. The timber used in turpentine operations in Louisiana and Texas is, however, generally of larger size than in the other States mentioned, so that a somewhat larger yield per crop under the same conditions would be expected, although not such a difference as shown in Table 16.

TABLE 16.—*Average yields in turpentine operations, by States,*[1] *during 1909.*

State.	Yield of turpentine per crop.	Percentage of gum secured by cupping.	State.	Yield of turpentine per crop.	Percentage of gum secured by cupping.
	Barrels.			*Barrels.*	
Alabama	35.6	8	Louisiana	44.7	44
Florida	29.8	16	Mississippi	34.5	11
Georgia	26.5	9	Texas	43.5	49

[1] Taken from statistical report on naval stores by Brower and La Fontissee.

Table 17 shows the new crops started by the box and cup methods in 1909, 1908, and 1907. The figures indicate that the cup method is steadily gaining ground; they also show that North Carolina and South Carolina at present play very little part in the production of naval stores.

TABLE 17.—*New crops started by box and cup methods in 1909, 1908, and 1907.*[1]

State.	Crops—1909.			Crops—1908.			Crops—1907.		
	Boxed.	Cupped.	Per cent cupped.	Boxed.	Cupped.	Per cent cupped.	Boxed.	Cupped.	Per cent cupped.
Alabama	337	131	28.0	420	84	16.7	423	71	14.4
Florida	1,374	326	19.2	1,593	313	16.4	2,065	210	9.2
Georgia	1,026	120	10.5	1,182	101	7.9	1,482	139	8.6
Louisiana and Texas	92	135	59.5	163	113	40.9	97	67	40.9
Mississippi	181	90	33.2	252	49	16.3	288	40	12.2
North Carolina	6			15	1	6.3	3	1	25.0
South Carolina	42			41			91		

[1] Taken from census report for 1909, reported as virgin, yearling, and third-year faces worked in 1909. Later statistics are, unfortunately, not available.

POSSIBILITIES OF WESTERN PINES AS A SOURCE OF NAVAL STORES.

During 1911 and 1912 the Forest Service conducted experiments on western yellow pine in Arizona, on western yellow pine, Jeffrey pine, digger pine, singleleaf piñon, and lodgepole and sugar pine in California and northeastern Oregon, and western yellow pine and piñon pine in Colorado, to determine the quantity of crude gum which could be secured from these pines by the methods ordinarily employed in the turpentining of longleaf yellow pine in the Southeast.[1] The field work was supplemented by laboratory analyses to determine the quality of the gum.

Table 18 compares the yields obtained in Arizona with those obtained in experiments conducted on a commercial scale in Florida. The Arizona experiments show a yield from western yellow pine about four-fifths as great as that obtained from southern yellow pines on average operations in Florida in the same period of time. Weather conditions in Arizona, however, will allow only a 24, or possibly a 26-week season, as against 30 or 35 weeks in the Southeast, so that when the yields for the entire season are compared western yellow pine shows a production about two-thirds as great as that from southern yellow pine. The average proportions of rosin and turpentine in the gum were about the same in both regions, as was the composition of the turpentine.

TABLE 18.—*Comparison of yields, in pounds, of crude gum and scrape from western yellow pine in Arizona and longleaf pine in Florida.*

Locality.	Crop designation.	Total weight obtained during season.		Average per cup per week.	
		Dip.	Scrape.	Dip.	Scrape.
Arizona [1]	A	2, 862. 50	523. 75	0. 239	0. 0436
Do	B	2, 524. 25	314. 75	. 210	. 0262
Do	C	2, 421. 75	288. 25	. 203	. 0240
Average		2, 606. 16	375. 58	. 217	. 0313
Florida [2]	A	63, 615. 5	9, 570	. 256	. 0386
Do	B	61, 161. 5	7, 650	. 246	. 0308
Do	C	62, 587	7, 245	. 252	. 0292
Do	D	73, 703. 5	8, 880	. 297	. 0358
Average		65, 266. 9	8, 336	. 263	. 0336

[1] Each crop of 500 cups chipped 24 times. [2] Each crop of 8,000 cups chipped 31 times.

The California experiments on western yellow pine were carried on from July 7 to November 1, 1911, and from May 10 to August 3, 1912. The yields obtained in 1911 and 1912 are combined in Table 19, to show the flow for an entire but not a continuous season.

[1] The California and Oregon experiments were made under the direction of Mr. C. Stowell Smith and Mr. J. B. Knapp, assistant district foresters, districts 5 and 6. A complete report of this work is on file at the Forest Service, Washington, D. C., and at the Forest Products Laboratory, Madison, Wis. For a detailed description of the Arizona and Colorado experiments see Forest Service Bulletin 116, "Possibilities of Western Pines As a Source of Naval Stores," by H. S. Betts.

TABLE 19.—*Yields of California western yellow pine, by months (crop of 300 cups, chipped 28 times).*

Date of dipping.	Weight of dip.	Date of dipping.	Weight of dip.
1912.	*Pounds.*	1911.	*Pounds.*
May 10–11	175	August 16	217
May 23	153	September 5	189
June 6–7	146	September 15	129
June 21	156	Septemer 27	172
July 6	171	October 19	179
July 20	197	November 1	152
August 3	260	November 28	212
Total	1,258	Total	1,250
		Total for 1912 and 1911	2,508
		Average per cup per week	0.3

The average flow per cup per week in the California experiments for a season of 29 weeks was somewhat greater than in the Florida experiments recorded in Table 18 for the same period of time. The California yield is also slightly greater when the production for the entire season is compared.

The composition of the volatile oil obtained by distilling the gum from the California trees differs from that of ordinary turpentine somewhat more than does the Arizona turpentine, but the oil probably will be satisfactory for industrial purposes. The yield from western yellow pine in northeastern Oregon was very small compared with that in California. This can be attributed in part to the unusually adverse climatic conditions during the season, but it is not likely that more favorable weather conditions would increase the yield enough to make turpentining in that region a profitable industry.

Jeffrey pine in California yielded only 61.5 per cent as much as western yellow pine farther south during the same period. The principal constituent of the oleoresin from Jeffrey pine is heptane, which can not be used as turpentine, but has been employed to some extent for medical purposes. Digger, piñon, lodgepole pine, and sugar pine in California were found to yield such small amounts of oleoresin that it would be impracticable to tap them on a commercial scale unless the particular oil they produce could be made to bring a high price for some special purpose.

Piñon pine (*Pinus edulis*) in Colorado had a rate of flow slightly over one-half that of the Florida pines for a 20-weeks' period, from June 9 to October 31. The volatile oil from the piñon gum differs somewhat from ordinary turpentine, but is probably suited for industrial use.

PROBLEMS OF COMMERCIAL DEVELOPMENT.

In considering the possibilities of commercial turpentine operations on western pines the problem of labor is one of the first that presents itself. In Arizona the Mexicans, who constitute a large part of the laboring class, are totally unfamiliar with turpentine work. Negro turpentine hands could be brought in from the Southeast, but

their transportation would be costly. A few negro hands might be secured to teach the Mexicans, but whether the results would be satisfactory is, of course, unknown. In California both Indian and white labor is available in many timbered portions that have turpentine possibilities, but here also the chippers would have to be taught how to use a hack.

The shorter season in Arizona, as compared with that of the Southeast, and the comparative severity of the winters in the timbered parts of the State, might make it necessary to discontinue operations entirely for a few months during the winter. This would necessitate the reorganization of the operating force each spring, with a great many attendant difficulties. The flow continued longer in California than in Arizona, the experimental areas in the former State showing a considerably higher average temperature than those in the latter, though the diurnal range of temperature in California was greater.

Western yellow pine timber generally grows in open stands free from underbrush, and in most cases there would be little, if any, more difficulty in moving the crude gum than in the Southeast. On rough ground burro pack trains might be used. Two small kegs or buckets, holding about 150 pounds of dip, could be slung on each animal.

The number of cups that can be hung on an acre of average western yellow pine compares favorably with the number hung on many areas now being turpentined in the Southeast. The western trees are larger than most of the southeastern ones, though their bark is thicker and rougher, and the outer portion must be removed before the trees are chipped. This, of course, means the expense of an extra step not necessary in southeastern operations. Such work can be done by the use of a broadaxe or heavy spade-shaped tool with a cutting edge.

The cost of securing turpentine rights in the Southeast is constantly rising, and it is likely that turpentine stumpage could be leased at lower rates in the West. At present the turpentine and rosin used in the West is shipped from the Gulf States, and the advantage of cutting out a two or three thousand mile haul to western markets is evident.

The naval stores industry is not new in California. During the Civil War when the supply of naval stores from the South was cut off an attempt was made to supply the northern States from the Pacific coast. The industry remained active for four or five years, but suddenly declined when North Carolina again came into the market after the close of the war.

The commercial success of turpentine operations in the Southwest will be doubtful until tried on a commercial scale. Nearly as much turpentine and rosin were obtained from western yellow pine as from

longleaf, and the amount of timber available for turpentine operations in the Southeast is constantly diminishing. These two facts make it reasonable to suppose that turpentine operations in the large tracts of virgin pine timber of the West will in time be justified.

SPECIAL PROBLEMS INVESTIGATED—ARIZONA AND CALIFORNIA WESTERN YELLOW PINE.

EVAPORATION FROM CUPS.

The rate of evaporation from the cups in Arizona was determined by exposing cups half full of fresh gum to the action of the air and weighing them at regular intervals. The samples of gum were secured by taking small amounts from as many of the cups as necessary on the first or second day after a fresh streak had been put on. Two samples were taken from each area after each dipping. Since dip is collected every three or four weeks in commercial operations the loss in weight during the first four weeks is the significant figure in the evaporation tests. Forty-eight evaporation samples were used. Of these 14 showed no loss at all in weight for the first four weeks; the remaining 34 samples showed losses ranging from 1.5 to 10.5 per cent. The average loss in weight for all the samples was 3 per cent. The gum as exposed contained turpentine, rosin, water, and chips. The loss by evaporation was of course made up of turpentine and water. The average loss of turpentine by evaporation from the cups in the Arizona experiments was therefore less than 3 per cent. The average loss in six similar evaporation tests in California was 2.5 per cent. No evaporation figures are available for southeastern operations.

COMPARISON OF YIELDS FROM NORTH AND SOUTH FACES—ARIZONA.

The total yield for 50 cups on the north side of 50 trees from the first dipping on June 3 to the last dipping on November 3 was 242.6 pounds and for 50 cups on the south side of the same trees 266.2 pounds. These weights show a 9 per cent greater flow on the south side of the trees than on the north. Figure 10 shows the average yield per week for both the north and south faces of each of the 50 trees, arranged in order of the yields from the south faces. Twenty-seven south cups yielded more than the corresponding north cups, while 17 north cups showed an excess over the corresponding south cups. The remaining six trees had about the same flow for both cups. The diagram shows the tendency of faces on the same tree to give the same yields. Trees having an exceptionally good or exceptionally poor flow generally show it in both faces.

EFFECT OF TEMPERATURE ON WEEKLY YIELD OF GUM.

Figure 11 shows the average flow per cup for 50 trees for each week and the corresponding average temperature. With but few excep-

tions the flow increased or decreased with increase or decrease of temperature. The effect of cool weather in checking the flow is especially marked toward the end of the season.

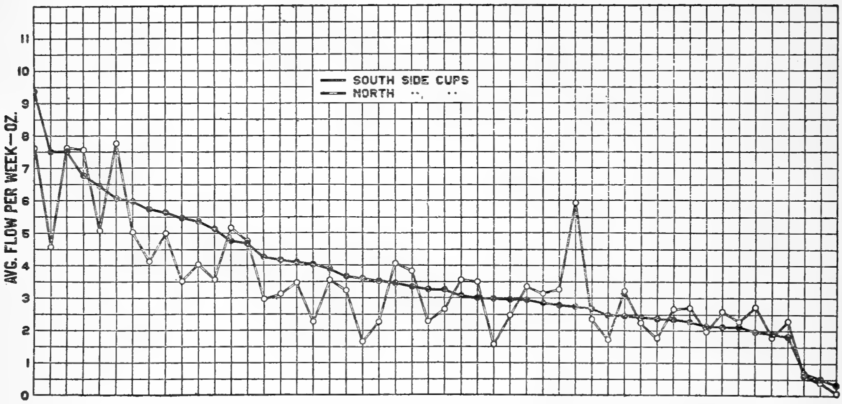

FIG. 10.—Comparison of flow from north and south faces of each of fifty trees.

RATE OF FLOW DURING WEEK.

Data on the variation in rate of flow were secured by weighing the north and south cups on 10 trees on the third day after each chipping throughout the season. The sum of the weights for each tree was compared with the weight of the total flow for the season from the

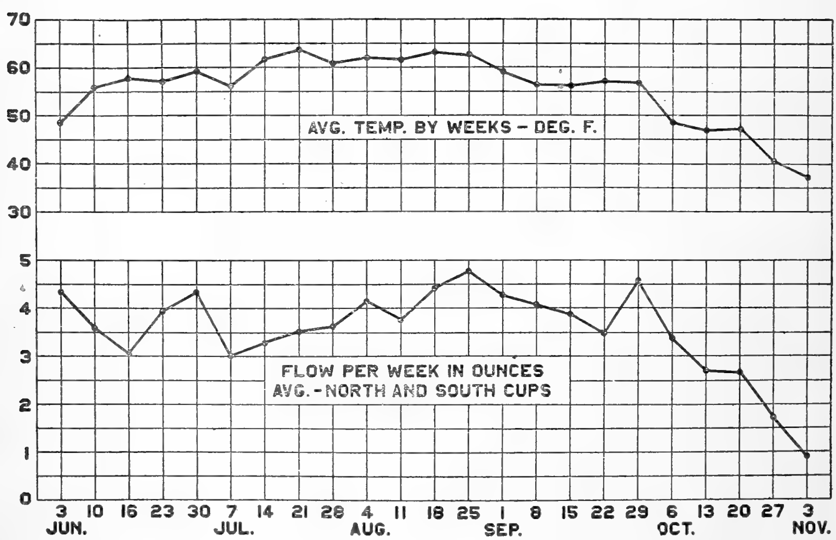

FIG. 11.—Relation between temperature and rate of flow of gum.

same trees. An average of the results shows that 73 per cent of the weekly flow occurred in the first three days. This ratio varied from 65 per cent to 78.6 per cent in the 10 test trees.

EFFECT OF VARYING FREQUENCY OF CHIPPING ON YIELD—CALIFORNIA.

Table 20 shows the yields obtained from three similar sets of 50 faces, each chipped at 3, 5, and 7 day intervals for the same period.

TABLE 20.—*Yields obtained by chipping at different intervals—California (50 faces in each set).*

3-day intervals.		5-day intervals.		7-day intervals.	
Date of chipping.	Weight of dip.	Date of chipping.	Weight of dip.	Date of chipping.	Weight of dip.
1912.	*Pounds.*	1912.	*Pounds.*	1912.	*Pounds.*
June 11....	46	June 14...	35½	June 13...	25
June 23....	49	June 29...	47	June 27...	31
July 5......	66	July 14....	49½	July 11....	31
July 17.....	69	July 29....	57	July 25....	40
July 29.....	81	Aug. 8....	45	Aug. 8....	45½
Aug. 10....	81	....	....	....	....
Total ..	392	....	234	....	172½

Over twice as much gum was obtained by chipping at 3-day intervals as at 7-day intervals.

SUGGESTIONS FOR SPECIFICATIONS.

HANGING CUPS

1. The distance from the ground to the apex of the first streak shall not exceed 10 inches.

2. No "blazes" or similar scarification of the tree shall extend below the gutter or apron. The surface prepared for the placement of the gutters or aprons shall not extend beyond the ends of the same.

3. The peak of the first streak shall not be more than 2 inches above the gutter or apron.

4. The "streak" or gash made for the placement of the gutters or aprons shall not penetrate the wood of the tree more than one-half inch, the measurement to be taken from the dividing line between the wood and bark.

5. The gutters or aprons must be so attached that no "gum" flows between the tree and the gutters or aprons, or flows over the edge of same so as to fall without the cup or other receptacle.

6. For the first three years the cups and gutters shall be raised each spring to the top of the face worked the previous season.

7. A bar or strip of live bark not less than 4 inches wide in the narrowest place shall be left between the faces.

CHIPPING.

1. No tree under 10 inches in diameter shall be tapped. Minimum diameter of tree to carry one face, 10 inches; minimum diameter of tree to carry two faces, 16 inches; no tree shall carry more than two faces.

2. The face on trees from 10 to 16 inches in diameter shall not exceed 12 inches in width, and the faces on trees above 16 inches in diameter shall not exceed 14 inches in width.

3. The height of the face shall not be increased by more than 16 inches each year the tree is tapped.

4. Each streak shall not exceed a width of one-half inch or a depth of one-half inch, the depth being measured from the dividing line between the wood and the bark.

5. Before the chipping season opens the rough outer bark shall be scraped off over the entire surface to be chipped for each season, care being taken not to penetrate the living bark.

6. During the winter a space of at least 2½ feet shall be raked free of débris about each tapped tree.

PACKING NAVAL STORES.

Buyers and exporters frequently complain that turpentine and rosin barrels reach them in poor condition, unfit for further shipment. In order to improve the standards of naval stores packages, the Savannah Board of Trade in 1911 issued letters of instruction to naval stores operators as follows:

Turpentine barrels.—All barrels, whether new or secondhand, should be kept absolutely protected from the elements, and not allowed to remain subject to rain and sunshine at way stations and river landings. Glue will not take on damp staves. Every barrel should be glued twice before being filled. Use only the best quality of glue, as it is the cheapest in the end. Before gluing, see that your pot is absolutely clean. Put into this 20 pounds of good glue and 5 gallons of water, and allow same to soak overnight. On the following morning apply sufficient heat to melt up to a temperature not exceeding 160° F. Under no condition whatever must glue be allowed to boil, as this causes decomposition to set in, which causes the bad smell usually noticed around glue sheds, and renders it utterly worthless. This amount of prepared glue will be sufficient for 20 barrels. After gluing, barrels should be taken off the trough and stood on the head for about one-half hour, after which time they should be reversed, so that the surplus glue will run down equally on both heads. The barrels should then be well and thoroughly driven, and after standing for 24 hours should be given a second coat of glue, using the exact formula as before. They are then ready to be filled in 48 hours, and if treated in this way there should be no turning except for broken staves.

Rosin.—Rule No. 9 of the Savannah Board of Trade says in part: "Rosin barrels to be in merchantable order must have two good heads, not exceeding 1½ inches in thickness, staves not to exceed 1 inch in thickness; the top well lined." Too much stress, therefore, can not be placed on the absolute necessity of carrying out this rule to the very letter, especially regarding the thickness of staves and heading, for rule No. 10 specifically instructs the inspector to make a proper deduction in weight on all rosin when the staves and headings are more than the prescribed thickness in rule No. 9. In such cases, therefore, the operator will lose, as in addition to having the deductions made, for which he receives nothing, he must pay the full amount of freight to the railroad. Operators must see that every barrel is well coopered before shipment; see that all four hoops are nailed on the barrels, and the heads cut to fit close, and a good lining hoop as prescribed by rule No. 9 is in place. Staves must be properly equalized. Staves should be 40 inches long, and barrels built on a 22-inch stress hoop, which gives a well-shaped and easily handled barrel.

EFFECT OF TEMPERATURE ON VOLUME OF TURPENTINE.

Operators often complain that the factor's gauge of their barrels is 1 or 2 gallons less than their own. When the barrel has not leaked, the difference is usually due to the temperature at which the turpentine was placed in the barrel. Very frequently the turpentine is at a temperature of from 50° to 60° C. (from 122° to 140° F.) when the barrels are filled, and later cools to, say, 25° C. The mean coefficient of expansion of turpentine between 10° and 40° C. is 0.000817 per degree.[1] By rough calculation, assuming a specific gravity of 0.8500 at 50° C., if the original 50 gallons have cooled 25 degrees, the loss of volume by contraction will be about 1.2 gallons.[2]

When the condenser is incapable of cooling the distillate to ordinary temperatures, the barrels after being filled with the warm turpentine should be loosely plugged and allowed to stand several hours, or until their contents have cooled to the temperature of the surrounding atmosphere. The barrels may then be filled up to the required volume.

COST ESTIMATES ON A 20-CROP TURPENTINE OPERATION.

The cost figures which follow do not apply to any single locality; they have been derived from several sources, and are believed to cover a fair range.

The yields [3] have been calculated from the data contained in Forest Service Bulletin 90. The dip is assumed to contain 15 per cent water and trash and 18.5 per cent turpentine, and the scrape 10 per cent trash and 11 per cent turpentine; while 1 gallon of turpentine is assumed to weigh 7.25 pounds.

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[1] Technologic Paper No. 9, Bureau of Standards, 1912.

[2] The following formula will give the expansion or contraction of turpentine due to temperature changes

$$V' = \frac{GV}{G \pm (T' - T)\,.000817}$$

where G and V are the specific gravity and volume at the temperature T, and V′ is the volume at the lower temperature T′.

[3] YIELDS PER CROP, CALCULATED FROM FOREST SERVICE BULLETIN 90.

First year—31 chippings:

83,495 lbs. dip, yielding	42.8 bbls. turpentine and	199.0 bbls. rosin.
12,560 lbs. scrape, yielding	3.8 bbls. turpentine and	35.4 bbls. rosin.
Total yield	46.6 bbls. turpentine and	234.4 bbls. rosin.

Second year—30 chippings:

74,791 lbs. dip, yielding	38.2 bbls. turpentine and	178.0 bbls. rosin.
14,818 lbs. scrape, yielding	4.5 bbls. turpentine and	41.8 bbls. rosin.
Total yield	42.7 bbls. turpentine and	219.8 bbls. rosin.

Third year—29 chippings:

57,324 lbs. dip, yielding	29.3 bbls. turpentine and	136.1 bbls. rosin.
13,399 lbs. scrape, yielding	3.6 bbls. turpentine and	38.3 bbls. rosin.
Total yield	32.9 bbls. turpentine and	174.4 bbls. rosin.

Fourth year—30 chippings:

45,100 lbs. dip, yielding	23.0 bbls. turpentine and	107.1 bbls. rosin.
19,908 lbs. scrape, yielding	6.0 bbls. turpentine and	56.2 bbls. rosin.
Total yield	29.0 bbls. turpentine and	163.3 bbls. rosin.

COST OF EQUIPMENT FOR A 20-CROP OPERATION.

1 25-barrel still, with shed and fixtures complete	$1,200.00 to	$1,250.00
20 shanties, at $50 to $75 each	1,000.00 to	1,500.00
2 houses, at $225 to $300 each	450.00 to	600.00
1 commissary	200.00 to	225.00
Sheds and stables	175.00 to	200.00
Tools	100.00 to	125.00
170 to 200 dip barrels, at $2.50 each	425.00 to	500.00
8 mules, at $200 to $250 each	1,600.00 to	2,000.00
4 wagons and harness, at $75 to $80	300.00 to	320.00
2 horses and saddles for woodsmen, $150 to $175	300.00 to	350.00
1 buggy and harness	75.00 to	80.00
Cups and gutters for 20 crops, at $45 to $55 per thousand	9,450.00 to	11,550.00
	15,275.00 to	18,700.00

COST OF OPERATION AND MAINTENANCE OF ONE CROP FOR ONE SEASON OF 30 WEEKS

Hanging cups	$100.00 to	$125.00
Raking and burning	25.00 to	28.00
Chipping	277.00 to	300.00
Dipping	120.00 to	150.00
Scraping	25.00 to	35.00
Hauling dip and scrape to still	80.00 to	110.00
Distilling	45.00 to	50.00
Salary of woods rider	70.00 to	75.00
Salary of manager	50.00 to	100.00
Recruiting	10.00 to	30.00
Taxes and still license	15.00 to	20.00
Cotton batting, straining wire, oil, tools, etc	8.00 to	10.00
Depreciation on cups and gutters [1]	80.00 to	95.00
Depreciation on dip barrels	5.00 to	6.00
Depreciation on other equipment, at 10 per cent	27.00 to	33.00
Interest on total investment, at 8 per cent	60.00 to	75.00
Lease on timber, at $25 to $33 per 1,000 cups	262.50 to	346.50
	1,259.50 to	1,588.50

COST OF MARKETING ONE CROP.

Barrels and cooperage	$175.00 to	$200.00
Haul to shipping point	10.00 to	100.00
Selling commission, 2½ per cent	30.00 to	35.00
Inspection	8.00 to	10.00
Storage	5.00 to	10.00
Insurance, ½ per cent	6.00 to	7.00
	234.00 to	362.00

Cost of operation and maintenance of one crop	1,259.50 to	1,588.50
Cost of marketing one crop	234.00 to	362.00
Total cost for 1 crop	1,493.50	1,950.50
Cost for 20 crops	29,870.00 to	39,010.00

[1] The life of the cups and gutters is about 6 years.

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956403. McKoy, E. A. Turpentine cup. April 26, 1910.
961953. Gilmer, J. T. Sap or gum extractor. June 21, 1910.
963065. Pringle, G. C. Turpentine cup. July 5, 1910.
963066. Pringle, G. C. Support for turpentine cup. July 5, 1910.
969765. Bailey, F. Dipper for turpentine cups. September 13, 1910.
974717. Spaler, D. B. and Bryan, B. F. Turpentine separator. November 1, 1910.
984364. Erikson, C. O. Gum filter. February 14, 1911.

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